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QUANTIFICATION OF ECCENTRIC HAMSTRINGS STRENGTH IN ELITE ACADEMY FOOTBALLERS: CONSIDERATIONS FOR ASSESSMENT

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Abstract Quantification of eccentric hamstring strength within elite youth sporting populations is a contemporary issue within practice. The aim of the study was to identify the reliability of eccentric strength metrics obtained via isokinetic dynamometry (IKD) and the NordBord in an elite youth football population. Furthermore, relationships between the strength metrics exhibited by the two devices were observed, to ascertain whether level of performance on one device can indicate how athletes will perform on the other. Twenty-one elite academy footballers completed two measures of eccentric hamstring strength on each device (60°·s^{-1} and 180°·s^{-1}). Test-retest reliability was determined through Pearson correlation analysis. Relationships between strength metrics (IKD: PT, AvT and oPT at 60°·s^{-1} and 180°·s^{-1}; NordBord: PF, AvF, PT, AvT, ϴ) obtained on both devices were identified for analysis. Test-retest of both devices identified significant correlations for all eccentric strength metrics (P = ≤0.05). Significant unilateral (L) relationships between PT, AvT (IKD 60°·s^{-1}; 180°·s^{-1}), break angle (ϴ) (NordBord) angle peak torque (oPT) at 60°·s^{-1} and ϴ were identified (P = ≤0.05). Eccentric hamstring strength analysis on both the IKD and NordBord provide reliable information for practitioners, justifying their inclusion as one factor that may inform readiness to train and injury risk, within elite youth footballers. Although, careful consideration in relation to individual metrics must be given when informing decision making processes. Practitioners require clarity on the objectives of the assessment, what the strength metrics represent and how they provide insight into performance and injury risk.

Keywords screening, injury risk, performance, muscle assessment

Introduction

Quantification of eccentric hamstring strength (Ham_{ecc}) is an ongoing contemporary debate between academics and practitioners, due to the influence of the hamstring on knee function and the incidence of hamstring injuries within the modern game (Rhodes et al., 2020a; Chebbi, Chamari, Van Dyk, Gabbett, Tabben, 2020). Hamstring strain injuries (HSI) account for 12% of all injuries documented in professional football and represented 37% of all muscle injuries sustained (Ekstrand, Hägglund, Walden, 2011). On average 21.8% of all players sustain at least one hamstring injury during a given season with a football team with 25 players typically suffering 5–7 HSI each season, equivalent to between 80–90 days lost due to injury (Ekstrand, Walden, Hägglund, 2016). Representing a significant financial loss for clubs and potentially a large impact on team performance (Hägglund, Walden, Ekstrand, 2013). These patterns of injury are consistent across elite academy footballers, inhibiting player development (Read, Oliver, Croix, Myer, Lloyd, 2017). Interestingly, literature reports that approximately one-third of HSI recur; with the highest risk for injury recurrence being within the first two weeks of return to sport (Sherry, Best, 2004; Dalton, Kerr, Dompier, 2015). This high recurrence rate could potentially be attributed to how practitioners quantify injury risk, an athlete's progression through rehabilitation or a premature return to sport. The consequences of recurrence are high with recurrent hamstring strains being shown to result in significantly more time lost than the first incidence (Erickson, Sherry, 2017).

Reduced eccentric strength has been shown to correlate with an increased risk of injury with significant strength reductions post injury (Vicens-Bordas et al., 2020). It is widely accepted that eccentric training should be incorporated in an uninjured footballer's schedule, to develop eccentric strength of the hamstrings and to reduce HSI risk (Grieg, 2008; Opar, Piatkowski, Williams, Shield, 2013; Rhodes, McNaughton, Greig, 2018). This extends to the integration of its use within rehabilitation programmes post injury in footballers (Tyler, Schmitt, Nicholas, McHugh, 2017). Contemporary debate exists between sports performance practitioners within elite sport settings as to which metrics should be used to quantify functional strength and the optimum technology to obtain such information.

Eccentric strength is often quantified in practice through; peak force (PF), average force (AvF), peak torque (PT), average torque (AvT), angle of PT (°PT) and break angle (⊖) with variations described across literature (Rhodes et al., 2018; Rhodes, Alexander, Greig, 2020b). These metrics are utilised to inform practitioners and athletes of the functional strength profile of the musculature, also providing insight into muscle architecture (Opar et al., 2013; Rhodes et al., 2020b). Thus, informing injury risk reduction strategies, conditioning, and periodisation of training. Isokinetic and NordBord testing can both be used to quantify these metrics, with literature citing isokinetics as the gold standard (Hazdic, Sattler, Markovic, Veselko, Dervisevic, 2010). Although, the high cost, lack of portability and time-consuming assessment process in a time pressured environment causes barriers to its widespread use, for example when quantifying functional strength measures to inform readiness to train/play (Hazdic et al., 2010; Opar et al., 2013). The NordBord (Vald Performance) as an alternative is a portable, quick assessment tool that allows analysis of large groups, quickly and efficiently providing information on the same functional strength parameters (Timmins et al., 2015). That said, questions have been raised with regards the functionality of the contemporary assessment tools available on the market, querying the testing position (Aagaard et al., 1998; Croisier et al., 2002; Brockett et al., 2004). Traditionally the hamstrings assessment in the IKD is performed in a seated hip flexion position in comparison to the kneeling hip neutral position of the NordBord test. Importantly, the knee position in both devices presents similarity. Ensuring range through which the hamstrings are loaded remains consistent in both tests. Literature currently fails to examine any relationships between metrics exhibited on each device, nor does it provide any indication that a level of performance on one device, equates to the same on another.

Consideration should not be focussed on the nature of the test, but information the test provides, with the aim to provide an accurate insight into function (Greig, 2008). Consensus throughout literature highlights the importance of eccentric strength and its reduction in injury occurrence, injury risk and increased performance (Greig, 2008; Opar et al., 2013; Rhodes et al., 2018). Highlighting the importance of quantification. Consequently, there is a lack of research in elite youth populations in relation to isokinetic and eccentric hamstring strength assessment utilising both the IKD and NordBord. Although, both devices are heavily utilised in elite performance environments, the reliability of these devices in elite youth populations is not well described (Wiesinger, Gressenbauer, Kösters, Schardinger, Müller, 2020). Clarity is required with regards any similarity of the range of metrics obtained between the two devices, reliability of measures in an elite academy setting, relevance of the speed of testing and interpretation of this information in practice. Literature assessing the similarities between both pieces of equipment is limited to one known study (Wiesinger et al., 2020). They describe the similarities between measures and resultant surface electromyography (sEMG) activity when performing the tests of the hamstrings and surrounding musculature. Concluding weak relationships between PT measures on the Isokinetic Dynamometer (IKD) and NordBord (Vald Performance), greater muscle activity on the IKD and hip angle influencing the PT output or °PT when performing testing on either device (Wiesinger et al., 2020). Indicating a need to standardise hip position within both tests. Limitations of this work were attributed to its sole focus on two strength parameters (PT and °PT) alongside sEMG measures, restricting the practical interpretation of the results and link to injury mechanisms (Rhodes et al., 2018). In addition to this the discussion regarding the variation in speed of test and its significance was not acknowledged. Previous literature has failed to consider variation in testing speed and isolated to a single testing velocity, limiting the interpretation of data in relation to injury mechanisms (Dvir, 1991; Ayala, De Ste Croix, Sainz de Baranda, Santonja, 2012). Recent evidence however has shown significant effects of testing speed particularly within elite sporting populations advocating its use (Greig, 2008; Rhodes et al., 2018; Rhodes et al., 2020b).

Clarity of the mechanical output quantifying the functional eccentric strength of the hamstrings via the IKD and NordBord is required. Whereby similar metrics are obtainable on both devices, direct comparison is beneficial and required to inform practitioners of their use in an elite environment. Further, highlighting how an athlete performs on one device will not equate to the same level of performance on the other. Providing insight into these measures on both devices will guide injury risk reduction strategies and their use in quantifying progression within rehabilitation. The aim of the present study is to determine the reliability the measures obtained on the IKD and NordBord in elite academy footballers and establish any relationships between these metrics to indicate whether measures are transferrable guiding their use in an applied environment.

Material and Methods

Participants

Twenty-one elite youth footballers from a Premier League Category 1 Academy completed the present study, age 17.63 ±0.76 years; height 180.2 ±6.1 cm; body mass 72.5 ±9.9 kg. All players were in full training, free from injury and available for competitive selection. Any player who had returned from injury within two months leading to the study were not included. All participants provided written informed consent in accordance with department and faculty research ethics committees (STEMH), and in accordance with the Helsinki Declaration.

Experimental Design

Participants were required to complete familiarisation trials consistent with the testing procedure on the Biodex IKD (System 3, Biodex Medical Systems, Shirley, NY, USA) and NordBord (VALD Performance, Newstead, Queensland Australia) seven days prior to testing to negate potential learning effects (Hinman, 2000). All participants involved in the studies completed all testing between 13:00 and 17:00 hrs to account for the effects of circadian rhythm (Sedliak, Haverinen, Hakkinen, 2011) and in accordance with regular training and competition times. Participants performed an identical warm up protocol before testing on each piece of equipment. This was led by the clubs Sports Science staff and consisted of a 10-minute of supervised stationary cycling 1.5 W kg^{-1}, cadence of 60 rpm on a cycle ergometer (Wattbike Ltd, Nottingham, UK). Followed by 10 full weight bearing bilateral squats, 10 unilateral left and right lunges, finishing with a dynamic hamstring stretching routine.

All players completed the strength testing across the two devices over 4 testing sessions, with 72 hrs between each bout of testing session, alternating between the NordBord and IKD respectively.

Eccentric Hamstring Strength

Data collection on the IKD (System 3, Biodex Medical Systems, Shirley, NY, USA) consisted of 2 × 3 repetitions of Ham_{ecc} work, which was followed by passive movement back into knee flexion guided by the IKD at $10°\cdot s^{-1}$. Each subject completed a unilateral isokinetic eccentric protocol on each limb, where dominant leg as defined as preferred kicking leg (van Melick et al., 2017) was carried out first. Gravity-corrected PT, AvT and ^{o}PT of the knee flexors were assessed at $60°\cdot s^{-1}$ and $180°\cdot s^{-1}$. Gravity correction was taken by weighing the athlete's limb weight on the IKD. Three repetitions were performed on each limb at each speed allowing 10 seconds recovery between efforts and a 2-minute recovery between sets (Greig, 2008). The IKD setup was modified to be subject specific following the manufacturer's guidelines and maintained throughout the exercise protocol. Participants were secured in a seated position consistent with previous approaches (Askling, Karlsson, Thorstensson, 2003; Greig, 2008; Rhodes et al., 2018). Restraints were applied across the thigh, proximal to the knee joint so as not to restrict movement, shoulders and chest (Rhodes et al., 2018). The crank axis was aligned with the axis of rotation of the knee joint, and the cuff of the IKD lever arm was secured at the ankle, proximal to the malleoli. Range of motion (ROM) was pre-set from full knee extension to a 95° range of knee flexion (Greig, 2008). The order of speeds performed was in line with recommendations that IKD protocols should be progress from slower to faster speeds (Wilhite et al., 1992). Verbal encouragement was provided consistently throughout the testing process as this replicated the encouragement they traditionally receive during performance (Knicker, Renshaw, Oldham, Cairns, 2011; Wiesinger et al., 2020).

Each subject performed three trials of NHE lowers on the NordBord. Each trial was recorded from the sagittal plane using a Canon XA35 camera at 50 Hz. The camera was placed on a fixed stand set 3 m away and 0.5 m from the floor (Rhodes et al., 2020a). Each participants' ϴ (lowest, closest to the floor) was calculated by using reflective markers placed on the skin of the anatomical landmarks previously set with the best repetition used for the purpose of the research (Rhodes et al., 2020a), which included; right greater trochanter, lateral femoral condyle, and lateral malleolus (Lee, Mok, Chan, Yung, Chan, 2017). Minimal clothing was recommended to avoid movement of markers. Participants were positioned on the NordBord replicating previous study protocols (Timmins et al., 2015; Bourne et al., 2017). Participants knelt on the padded section of the NordBord with each ankle secured superior to the lateral malleolus by individual braces. Participants were instructed to gradually lean forward at the slowest possible speed, from the upright position (90° knee flexion) maximally resisting this movement with both limbs, while holding their trunk and hips in a neutral position throughout, with their hands across their chest (Buchheit et al., 2016). Performance of the Nordic exercise was completed at –20 to –40°·s^{-1} in line with previous work (Opar et al., 2013; Wiesinger et al., 2020). Failure to perform at this speed resulted in repeated trials. Individual's knee position on the NordBord was recorded using the integrated knee position guides with the ankle restraints at 90°, 2 cm superior to the lateral malleolus to ensure the body position remain consistent between tests. The NHE completed on the NordBord was analysed using a variation of the motion analysis protocol adopted from previous studies (Rhodes et al., 2020a). Video clips were digitized and transformed into a two-dimensional space using motion analysis application software (IOS Nordics Application). ϴ was ascertained by utilising the break point frame in the application. The three markers were placed on the reflective markers on the anatomical landmarks of 1) lateral malleolus; 2) lateral femoral condyle and 3) greater trochanter.

Data Analysis

IKD gravity corrected torque-angle curve was analysed for both testing speeds, with analysis restricted to the isokinetic phase. The repetition eliciting the highest peak torque was identified for subsequent analysis. Peak torque (PT), the corresponding angle (°PT), and the average torque across the isokinetic phase (AvT) were identified for each player, at each testing speed (Greig, 2008; Rhodes et al., 2018). NordBord strength metrics of peak force (PF), average force (AvF), peak torque (PT) and average torque (AvT) were determined utilising Vald Performance LTD IOS Application NordBord Hamstring Testing System ver. 1.1.2. Break angle (ϴ) was determined by identifying the largest angle produced within the 3 repetitions individually for each player.

Statistical Analysis

Data is presented as mean ± SD and 95% confidence limits. Statistical significance was set at $P \leq 0.05$. Statistical analysis was performed using SPSS (V26, SPSS Inc, Chicago, IL). Pearson's correlation coefficients (r) were calculated to quantify the test-retest relationship and the linear relationship between IKD and NordBord profiles. Further correlation coefficient (r) analysis was completed to quantify the linear relationship between strength metrics from the IKD at both testing speeds (60°·s^{-1} and 180°·s^{-1}) and NordBord strength parameters. Coefficient of correlation (r) and respective level of significance (p value) describes total variance. The following criteria quantified magnitude of the correlation <0.1, trivial; >0.1 to 0.3, small; >0.3 to 0.5, moderate; >0.5 to 0.7, large; >0.7 to 0.9, very large; and >0.9 to 1.0, almost perfect (Mukaka, 2012).

Results

Tables 1 and 2 summarise the mean ± standard deviation scores achieved for the test-retest of the IKD and NordBord respectively, representing a plethora of strength metrics observed on each device.

Table 1. Displaying mean and standard deviation scores for test-retest of IKD strength metrics at 60 o/s^{-1} and 180 o/s^{-1}

Speed °/s^{-1}	Week 1						Week 2					
	PT (L)	PT (R)	AvT (L)	AvT (R)	°PT (L)	°PT (R)	PT (L)	PT (R)	AvT (L)	AvT (R)	°PT (L)	°PT (R)
60	153.01 ±15.10	158.69 ±14.37	116.57 ±15.13	120.20 ±14.63	48.07 ±10.46	45.86 ±11.51	155.30 ±14.05	160.36 ±19.90	119.28 ±14.13	118.83 ±11.81	48.09 ±10.27	45.27 ±11.56
180	126.61 ±21.91	129.23 ±19.885	109.85 ±15.71	106.36 ±18.50	55.83 ±13.26	61.03 ±11.20	128.34 ±20.05	127.54 ±19.579	110.85 ±18.93	106.01 ±17.13	54.54 ±13.15	57.50 ±14.17

Table 2. Displaying mean and standard deviation scores for test-retest of NordBord strength metrics

	Week 1									Week 2								
	PT (L)	PT (R)	AvT (L)	AvT (R)	PF (L)	PF (R)	AvF (L)	AvF (R)	Break Angle	PT (L)	PT (R)	AvT (L)	AvT (R)	PF (L)	PF (R)	AvF (L)	AvF (R)	Break Angle
N	150.4 ±33.36	157.98 ±35.45	141.77 ±35.49	147.4 ±36.23	380.4 ±53.65	400.2 ±59.31	356.5 ±60.34	371.3 ±63.20	38.5 ±8.87	149.55 ±34.53	155.57 ±33.93	134.74 ±31.58	142.74 ±32.44	377.1 ±62.91	397.6 ±57.50	344.1 ±63.04	366.8 ±63.39	38.18 ±8.28

Statistically significant correlation coefficients were displayed for all metrics on both the IKD and NordBord. *IKD*: PT (L) 60°·s^{-1}: r = 0.878, p = 0.000, CI = 0.724–0.943; PT (R) 60°·s^{-1}; r = 0.923, p = ≤0.001, CI = 0.839–0.972; PT (L) 180°·s^{-1}: r = 0.881, p = ≤0.001, CI = 0.650–0.976; PT (R) 180°·s^{-1}: 0.880, p ≤ 0.001, CI = 0.763–0.955; AvT (L) 60°·s^{-1}: r = 0.878, p = ≤0.001, CI = 0.724–0.943; AvT (R) 60°·s^{-1}: r = 0.911, p = ≤0.001, CI = 0.729–0.973; AvT (L) 180°·s^{-1}: r = 0.874, p = ≤0.001, CI = 0.652–0.970; AvT (R) 180°·s^{-1}: r = 0.881, p = ≤0.001, CI = 0.746–0.970; °PT (L) 60°·s^{-1}: r = 0.878, p = ≤0.001, CI = 0.724–0.943; °PT (R) 60°·s^{-1}: r = 0.914, p ≤ 0.001, CI = 0.836–0.974; °PT (L) 180°·s^{-1}: r = 0.899, p = ≤0.001, CI = 0.797–0.967; °PT (R) 180°·s^{-1}: r = 0.896, p = ≤0.001, CI = 0.745–0.962. NordBord: PF (L): r = 0.906, p = ≤0.001, CI = 0.798–0.962; PF (R): r = 0.792, p = ≤0.001, CI = 0.571–0.924; PT (L): r = 0.763, p = ≤0.001, CI = 0.510–0.946; PT (R): r = 0.603, p = ≤0.001, CI = 0.285–0.876; AvF (L): r = 0.891, p = ≤0.001, CI = 0.762–0.957; AvF (R): r = 0.852, p = ≤0.001, CI = 0.688–0.938; AvT (L): r = 0.575, p = 0.013, CI = 0.246–0.839; AvT (R): r = 0.557, p = 0.016, CI = 0.220–0.820; ϴ – r = 0.922, p = ≤0.001, CI = 0.820–0.953.

Further correlation coefficient analysis of the NordBord and IKD metrics to examine relationships between the two devices predominantly displayed no significant correlations between any of the strength metrics taken (p > 0.05).

Table 3. Displaying Correlations for all Eccentric Strength Metrics Obtained on the NordBord against the IKD

Specification	PF (L)	PF (R)	PT (L)	PT (R)	AvF (L)	AvF (R)	AvT (L)	AvT (R)	Break Angle
1	2	3	4	5	6	7	8	9	10
PT (L) 60°·s^{-1}	r = 0.256, p = 0.338, CI = –0.247–0.702	r = 0.079, p = 0.773, CI = –0.438–0.562	r = –0.006, p = 0.982, CI = –0.541–0.626	r = –0.150, p = 0.580, CI = –0.629–0.486	r = 0.055, p = 0.838, CI = –0.521–0.638	r = –0.013, p = 0.961, CI = –0.566–0.528	r = –0.102, p = 0.707, CI = –0.625–0.586	r = –0.169, p = 0.531, CI = –0.684–0.516	r = –0.555, p = 0.026, CI = –0.790–0.260*
PT (R) 60°·s^{-1}	r = 0.260, p = 0.331, CI = –0.177–0.674	r = 0.237, p = 0.377, CI = –0.172–0.572	r = 0.168, p = 0.533, CI = –0.319–0.712	r = 0.143, p = 0.598, CI = –0.306–0.579	r = 0.153, p = 0.571, CI = –0.265–0.627	r = 0.143, p = 0.597, CI = –0.232–0.544	r = 0.127, p = 0.638, CI = –0.334–0.687	r = 0.073, p = 0.787, CI = –0.360–0.581	r = –0.418, p = 0.107, CI = –0.811–0.071
AvT (L) 60°·s^{-1}	r = 0.291, p = 0.271, CI = –0.193–0.718	r = 0.083, p = 0.761, CI = –0.386–0.551	r = 0.059, p = 0.827, CI = –0.483–0.712	r = –0.110, p = 0.684, CI = –0.583–0.535	r = 0.106, p = 0.696, CI = –0.440–0.691	r = 0.007, p = 0.981, CI = –0.495–0.535	r = –0.028, p = 0.919, CI = –0.543–0.703	r = –0.130, p = 0.632, CI = –0.633–0.565	r = –0.551, p = 0.027, CI = –0.808–(–0.242)*
AvT (R) 60°·s^{-1}	r = 0.400, p = 0.125, CI = 0.062–0.748	r = 0.379, p = 0.148, CI = 0.038–0.641	r = 0.295, p = 0.267, CI = –0.116–0.716	r = 0.269, p = 0.314, CI = –0.161–0.614	r = 0.329, p = 0.214, CI = –0.003–0.708	r = 0.312, p = 0.240, CI = –0.022–0.604	r = 0.279, p = 0.295, CI = –0.124–0.727	r = 0.220, p = 0.412, CI = –0.232–0.607	r = –0.214, p = 0.426, CI = –0.777–0.329
PT (L) 180°·s^{-1}	r = 0.242, p = 0.367, CI = –0.219–0.652	r = 0.110, p = 0.686, CI = –0.386–0.630	r = 0.055, p = 0.841, CI = –0.517–0.706	r = –0.036, p = 0.896, CI = –0.613–0.737	r = 0.102, p = 0.707, CI = –0.426–0.652	r = 0.071, p = 0.793, CI = –0.481–0.637	r = –0.004, p = 0.987, CI = –0.589–0.713	r = –0.021, p = 0.939, CI = –0.633–0.756	r = –0.593, p = 0.016, CI = –0.817–(–0.286)*

1	2	3	4	5	6	7	8	9	10
PT (R) 180°·s^{-1}	r = 0.278, p = 0.298, CI = –0.258–0.758	r = 0.123, p = 0.650, CI = –0.352–0.681	r = 0.178, p = 0.510, CI = –0.361–0.659	r = 0.034, p = 0.901, CI = –0.425–0.558	r = 0.099, p = 0.716, CI = –0.464–0.600	r = –0.018, p = 0.949, CI = –0.477–0.509	r = 0.062, p = 0.819, CI = –0.447–0.582	r = –0.029, p = 0.916, CI = –0.480–0.479	r = –0.278, p = 0.297, CI = –0.682–0.207
AvT (L) 180°·s^{-1}	r = 0.333, p = 0.208, CI = –0.150–0.739	r = 0.186, p = 0.491, CI = –0.288–0.658	r = 0.214, p = 0.425, CI = –0.433–0.772	r = 0.096, p = 0.724, CI = –0.526–0.745	r = 0.212, p = 0.432, CI = –0.335–0.757	r = 0.167, p = 0.536, CI = –0.386–0.679	r = 0.151, p = 0.577, CI = –0.490–0.770	r = 0.119, p = 0661, CI = –0.509–0.762	r = –0.616, p = 0.011, CI = –0.833–(–0.300)*
AvT (R) 180°·s^{-1}	r = 0.391, p = 0.134, CI = –0.135–0.821	r = 0.284, p = 0.286, CI = –0.192–0.787	r = 0.371, p = 0.157, CI = –0.158–0.776	r = 0.249, p = 0.352, CI = –0.249–0.711	r = 0.249, p = 0.353, CI = –0.324–0.706	r = 0.176, p = 0.514, CI = –0.322–0.681	r = 0.265, p = 0.321, CI = –0.302–0.712	r = 0.200, p = 0.457, CI = –0.295–0.664	r = –0.346, p = 0.190, CI = –0.702–0.179
ºPT (L) 60°·s^{-1}	r = –0.235, p = 0.382, CI = –0.699–0.311	r = –0.145, p = 0.591, CI = –0.569–0.296	r = –0.094, p = 0.728, CI = –0.600–0.382	r = 0.008, p = 0.978, CI = –0.427–0.391	r = –0.075, p = 0.783, CI = –0.560–0.460	r = –0.040, p = 0.882, CI = –0.465–0.420	r = 0.012, p = 0.964, CI = –0.498–0.462	r = 0.059, p = 0.828, CI = –0.422–0.461	r = 0.504, p = 0.047, CI = 0.018–0.867*
ºPT (R) 60°·s^{-1}	r = –0.375, p = 0.152, CI = –0.755–0.171	r = –0.335, p = 0.205, CI = –0.659–0.150	r = –0.402, p = 0.123, CI = –0.772–(–0.003)	r = –0.354, p = 0.178, CI = –0.665–0.039	r = –0.384, p = 0.142, CI = –0.731–0.019	r = –0.350, p = 0.184, CI = –0.644–0.025	r = –0.433, p = 0.094, CI = –0.755–(–0.092)	r = –0.398, p = 0.127, CI = –0.672–(–0.047)	r = 0.546, p = 0.029, CI = 0.095–0.828*
ºPT (L) 180°·s^{-1}	r = –0.343, p = 0.194, CI = –0.754–0.172	r = –0.313, p = 0.238, CI = –0.694–0.227	r = –0.159, p = 0.556, CI = –0.603–0.298	r = –0.132, p = 0.627, CI = –0.555–0.342	r = –0.227, p = 0.398, CI = –0.643–0.294	r = –0.225, p = 0.402, CI = –0.584–0.220	r = –0.114, p = 0.675, CI = –0.548–0.337	r = –0.118, p = 0.663, CI = –0.544–0.353	r = –0.485, p = 0.06, CI = 0.006–0.814
ºPT (R) 180°·s^{-1}	r = –0.222, p = 0.409, CI = –0.802–0.487	r = –0.052, p = 0.847, CI = –0.578–0.474	r = –0.045, p = 0.868, CI = –0.605–0.540	r = 0.099, p = 0.716, CI = –0.385–0.535	r = –0.125, p = 0.645, CI = –0.688–0.513	r = –0.004, p = 0.989, CI = –0.507–0.503	r = –0.014, p = 0.958, CI = –0.555–0.529	r = 0.086, p = 0.751, CI = –0.402–0.525	r = –0.327, p = 0.217, CI = –0.161–0.723

* Denotes significance 0.05 level.
Confidence Intervals at 95%.

Statistically significant correlations were identified for NordBord ϴ and PT (L) 60°·s^{-1}: r = –0.555, p = 0.026, CI = –0.790–0.260; NordBord ϴ and AvT (L) 60°·s^{-1}: r = –0.551, p = 0.027, CI = –0.808–(–0.242); Nordbord ϴ and PT (L) 180°·s^{-1}: r = –0.593, p = 0.016, CI = –0.817–(–0.286); AvT (L) 180°·s^{-1}: r = –0.616, p = 0.011 CI = –0.833–(–0.300); NordBord ϴ and ºPT (L) 60°·s^{-1}: r = 0.504, p = 0.047, CI = 0.018–0.867; NordBord ϴ and ºPT (R) 60°·s^{-1}: r = 0.546, p = 0.029, CI = 0.095–0.828.

Discussion

The aim of the study was to establish the reliability of quantifying Ham_{ecc} in elite youth footballers using the IKD and NordBord. Although the reliability of eccentric strength measures on both devices have been ascertained in an adult sporting population, it is not represented in elite academy footballers, despite the widespread use of these metrics in a practical setting (Greig, 2008; Opar et al., 2013). Additionally, the recent work by Wiesinger et al. (2020) does not consider PF, AvF and ϴ for comparison. This work is also completed in a non-sporting adult population. Further highlighting the need for the present study. The present study analyses the relationships between multiple metrics of PF, PT, AvF, AvT, ºPT and ϴ between the IKD and NordBord were quantified. A limitation exhibited in the present work was both testing devices were completed in their traditional positions. However, the focus of the work was to load the hamstrings through similar knee ranges, with replicable start and end ranges in both pieces of testing equipment. The findings in the present study identified that the IKD was shown to have very large to almost perfect correlations across all parameters for the two testing speeds utilised (0.87–0.91). These results are contradictory to previous research, which both reported poor correlations (Dvir, 1991; Ayala et al., 2012) and thus advocate the use of a variety of testing speeds within this population to allow greater association to be made between function and injury mechanisms (Greig, 2008; Rhodes et al., 2018). In contrast, the variation of coefficient of correlation measures obtained for the NordBord in the current study displayed greater variance, contradicting previous research completed in senior elite sports populations reporting large to perfect correlations in PF and AvF values (Opar et al., 2013). Specifically, PF and AvF exhibited large to almost perfect relationships (0.79–0.91), moderate to large correlations (0.56–0.76) and ϴ showing almost perfect correlations (0.92). Interestingly, greater variance in metrics were seen on the right limb for PF and PT, this was also displayed in AvF and AvT, albeit the difference between right and left being smaller. Reasons for this are unclear, however, it is suggested this could potentially be associated with the bilateral nature of the exercise (Opar et al., 2013; Timmins et al., 2015) and the larger group of muscle recruitment required to perform the exercise (Wiesinger et al., 2020). This may highlight deficiencies in elite youth footballers that could contribute to sustaining lower limb injury (Rhodes et al., 2020a). Practitioners and future research should consider electromyographic analysis of the musculature during performance of the test to identify asymmetry.

Correlation analysis of the functional strength metrics across both devices identified significant moderate correlations for °PT (L) and (R) $60°\cdot s^{-1}$ and ϴ ($r = 0.50–0.55$). Interestingly (L) sided measures of PT and AvT at $60°\cdot s^{-1}$ and $180°\cdot s^{-1}$ highlighted significant negative correlation with ϴ. Suggesting players with greater (L) PT/AvT values at both speeds presented with lower ϴ scores, highlighting a greater range under eccentric tension when performing the NHE. In addition to this, significant moderate correlations were found between °PT (L) and (R) $60°\cdot s^{-1}$ and ϴ. It is important to note that the lower angles attained from measures of °PT and ϴ, both represented values where the knee was in a greater degree of extension, making it more relatable to hamstrings mechanism of injury. The faster speed of $180°\cdot s^{-1}$ did not show any significant relationship between °PT and ϴ, suggesting that strength response changes in response to faster speed exposure. This provides considerations for practitioners when conditioning athletes in relation to specific game play demands and may contribute to the discussion of maximum velocity exposure (Mendiguchia et al., 2020). Caution must be taken with regards the interpretation of these findings. Although, significant correlations were found, in line with previous research (Sconce, Jones, Turner, Comfort, Graham-Smith, 2015), it is important to note these were moderate and further work should consider a larger population of elite youth athletes. Break angle on the NordBord was calculated bilaterally and future work should consider analysis of the relationship between break point angle and the sum (or average) of the left or right limb on the NordBord and IKD. Interpretation of these findings and translation to practice is important. Within this elite youth population, either device could be utilised to determine an individual's functional strength and gain some insight into the muscle architecture. This said, thought must be given to the specific metrics utilised to quantify functional strength, what they represent and how they relate to injury mechanisms and functional performance. Lastly, future work should consider the youth players maturation status, as this may affect physical or predicted outputs in relation to strength assessments.

PF represents the maximum force exerted when performing the NHE, with AvF representing the average force output through range. Research has indicated that PF and AvF are relative to body mass (Buchheit et al., 2016), although higher values of PF and AvF reduce the chance of sustaining hamstring injury (Timmins et al., 2015; Roe et al., 2018). Consequently, any quantification of PF or AvF utilising the NordBord should consider body mass assessment of the athlete (Bucheit et al., 2016). There is limited literature that exists discussing PT and AvT within

NordBord testing. Significantly, IKD research focusses heavily on these two metrics (Greig, 2008; Ayala et al., 2012; Rhodes et al., 2018). PT representing the peak output achieved through range at a given speed and AvT representing a measure of the average exerted in relation to testing speed (Small, McNaughton, Greig, Lovell, 2009). Within the present study, reliability findings associated with the NordBord indicate that reliance on these strength metrics may be questioned. Perhaps providing an insight in to why they are not heavily utilised within literature. It is suggested that these metrics obtained via NordBord testing should not be considered for use in practice within an elite youth sports population. ϴ and °PT provide insight into the muscle architecture of the hamstrings. Detailing muscle length in relation to when it can no longer sustain the force applied or at which point the muscle is exerting its maximal force through the repetition (Greig, 2008), both devices exhibit almost perfect reliability. Thought should be given to the bilateral nature of the NHE, as ϴ represents both (L) and (R) limbs. Alternatively, the IKD provides a unilateral analysis of °PT. Within athletes where asymmetry in function is suspected, for example post injury, practitioners should consider IKD analysis due to its unilateral nature.

Questions in practice have been raised in relation to the functionality of both devices, with literature highlighting the variance of testing speed on the IKD increases its relevance to injury mechanism and performance (Dvir, 1991; Ayala et al., 2012). The importance of the slow and controlled eccentric function of the hamstring during deceleration within performance could provide evidence of the functional relevance of the NordBord device. This exercise is completed in a controlled manner, with the athlete dictating speed of control. PF and AvF may provide greater awareness into an athlete's preparedness for this load during performance. During deceleration movements within performance the musculature has been shown to be under the most force increasing injury risk (Harper, Kiely, 2018). PF potentially provides insight into why greater functional strength outputs are related to lower limb injury occurrence (Timmins et al., 2015). To ensure the functionality of the PF output this must be considered along with ϴ, as it will provide information to where the PF is exerted in relation and links to injury mechanism can be made by practitioners.

It is important to note a singular metric on either device is not enough to draw conclusions on an athlete's functional strength in relation to performance and injury risk. Practical considerations in relation to the reliability of metrics utilised and the time allocated to assess players function must be considered. It is suggested that either device can provide Sports Medicine or Performance practitioners with a clear insight into the athlete's functional strength, when metrics analysed are considered carefully. Practitioners should consider the reliability of metrics within their population, before considering their use.

Relationships between NordBord and IKD strength metrics are limited, with only significant moderate correlations identified between PT and ϴ at $60°\cdot s^{-1}$ and (L) AvT/PT and ϴ at both testing speeds. Eccentric hamstring strength analysis on both the IKD and NordBord provides reliable information for practitioners to evaluate readiness to train and injury risk, within elite youth footballers. Although, careful consideration must be given to the metrics utilised to guide decision making. IKD metrics were identified as being reliable bilaterally across all metrics (PT, AvT and °PT). The unilateral nature of the IKD may be advantageous in practice to draw definitive conclusions into the performance of the isolated limb. Completion of Norbord testing represents a bilateral exercise, where the performance of one limb may affect the output of the contralateral side. This said, NordBord measures of PF and break angle were highlighted as being highly reliable. Consideration must be given to what the strength metrics represent and how this provides insight into performance and injury risk. Eccentric strength analysis and subsequent conclusions drawn should not be made on information provided by isolated metrics. In practical settings it is important to consider reliability measures with the specific population prior to implementing testing protocols.

Practical Implications

1. Utilisation of a range of testing speeds on the IKD are beneficial to assess the functionality of the hamstring and provide the practitioner with valuable information to inform rehabilitation programming and injury risk reduction strategies.

2. ^{e}PT (60°·s^{-1}) and ϴ display moderate correlations, indicating practitioners can cautiously interpret that young athletes produce similar outputs on each device in relation to these strength metrics. These similarities may be seen due to the slow nature that each of these tests are performed. The reasons for only a moderate correlation, however, may be due to adapted technique performed during a Nordic hamstring curl, that may engage other musculature.

3. The variation of coefficient of correlation measures obtained for youth footballers on the NordBord displayed greater variance. Contradicting previous research completed in senior elite sports populations reporting large to perfect correlations in PF and AvF values.

4. Levels of performance on the IKD do not equate to the same levels of performance on the NordBord. Careful consideration must be given by practitioners to the utilisation of each device in the field, what the device measures and why the test is being performed.

References

Aagaard, P., Simonsen, E.B., Magnusson, S.P., Larsson, B, Dyhre Poulsen, P.A. (1998). New concept for isokinetic hamstring: quadriceps muscle strength ratio. *Am J Sports Med*, *26* (2), 231–237.

Askling, C., Karlsson, J., Thorstensson, A. (2003). Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scan J Med Sci Sports*, *13* (4), 244–250.

Ayala, F., De Ste Croix, M., Sainz de Baranda, P., Santonja, F. (2012). Absolute Reliability of Isokinetic Knee Flexion and Extension Measurements Adopting a Prone Position. *Clin Phys Func Imag*, *33* (1), 45–54.

Bourne, M.N., Duhig, S.J., Timmins, R.G., Williams, M.D., Opar, D.A., Najjar, A.A., Kerr, G.K., Shield, A.J. (2017). Impact of the Nordic hamstring and hip extension exercises on hamstring architecture and morphology: implications for injury prevention. *Br J Sports Med*, *51* (5), 469–477.

Brockett, C.L., Morgan, D.L., Proske, U. (2004). Predicting hamstring strain injury in elite athletes. *Med Sci Sports Ex*, *36* (3), 379–387.

Buchheit, M., Cholley, Y., Nagel, M., Poulos, N. (2016). The effect of body mass on eccentric knee-flexor strength assessed with an instrumented nordic hamstring device (NordBord) in football players. *Int J Sports Physiol Perform*, *11* (6), 721–726.

Chebbi, S., Chamari, K., Van Dyk, N., Gabbett, T., Tabben, M. 2020. Hamstring injury prevention for elite soccer players: A real-world prevention program showing the effect of players compliance on the outcome. *J Stren Cond Res*, Ahead of Print, 1–6.

Croisier, J.L., Forthomme, B., Namurois, M.H., Vanderthommen, M., Crielaard, J.M. (2002). Hamstring muscle strain recurrence and strength performance disorders. *Am J Sports Med*, *30* (2), 199–203.

Dalton, S.L., Kerr, Z.Y., Dompier, T.P. (2015). Epidemiology of hamstring strains in 25 NCAA sports in the 2009–2010 to 2013–2014 academic years. *Am J Sports Med*, *43* (11), 2671–2679.

Dvir, Z. (1991). Clinical Applicability of Isokinetics. A review. *Clin Biomech*, *6* (3), 133–144.

Ekstrand, J., Hägglund, M., Walden, M. (2011). Epidemiology of muscle injuries in professional football (soccer). *Am J Sports Med*, *39* (6), 1226–1232.

Ekstrand, J., Walden, M., Hagglund, M. (2016). Hamstring injuries have increased by 4% annually in men's professional football, since 2001: a 13-year longitudinal analysis of the UEFA elite club injury study. *Br J Sports Med*, *50* (12), 731–737.

Erickson, L., Sherry, M.A. (2017). Rehabilitation and return to sport after hamstring strain injury. *J Sport Health Sci*, *6* (3), 262–270.

Greig, M. (2008). The influence of soccer-specific fatigue on peak isokinetic torque production of the knee flexors and extensors. *Am J Sports Med*, *36* (7), 1403–1409.

Hägglund, M., Walden, M., Ekstrand, J. (2013). Risk factors for lower extremity muscle injury in professional soccer: the UEFA Injury Study. *Am J Sports Med*, *41* (2), 327–335.

Harper, D.J., Kiely, J.K. (2018). Damaging nature of decelerations: Do we adequately prepare players? *BMJ Open Sport Ex Med*, *6* (4), e000379.

Hazdic, V., Sattler, T., Markovic, G., Veselko, M., Dervisevic. (2010). The isokinetic strength profile of quadriceps and hamstrings in elite volleyball players. *Isokinetics Ex Sci*, *18*, 31–37.

Hinman, M. (2000). Factors affecting reliability of the biodex balance system: A summary of four Studies. *J Sport Rehab*, *9* (3), 240–252.

Knicker, A.J., Renshaw, I., Oldham, A.R.H., Cairns, S.P. (2011). Interactive processes link the multiple symptoms of fatigue in sport competition. *Sports Med*, *41*(4), 307–328.

Lee, J.W.Y., Mok, K, Chan, H.C.K., Yung, P.S.H., Chan, K. (2017). Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. *J Sci Med Sport*, *21* (8), 789–793.

Mendiguchia, J., Conceicao, F., Edouard, P., Fonseca, M., Pereira, R., Lopes, H., Morin, J.B., Reyes, P.J. (2020). Sprint versus isolated eccentric training: Comparative effects on hamstring architecture and performance in soccer players. *PLOS One*, *15* (2), e0228283.

Mukaka, M.M. (2012). A guide to appropriate use of correlation coefficient in medical research. *Malawi Med Jour*, *24* (3), 69–71.

Opar, D.A., Piatkowski, T, Williams, M.D., Shield, A.J. (2013). A novel device using the nordic hamstring exercise to assess eccentric knee flexor strength: a reliability and retrospective injury study. *J Orthop Sports Phys Ther*, *43* (9), 636–640.

Read, P.J., Oliver, J.L., Croix, D.S., Myer, G.D., Lloyd, R.S. (2017). A prospective investigation to evaluate risk factors for lower extremity injury risk in male youth soccer players. *Scan J Med Sci Sports*, *28* (3), 1244–1251.

Rhodes, D., Jeffery, J., Maden-Wilkinson, J., Reedy, A., Morehead, E., Kiely, J., Birdsall, D., Carling, C., Alexander, J. (2020a). The relationship between eccentric hamstring strength and dynamic stability in elite academy footballers. *Sci Med Football*, In Press, 1–7.

Rhodes, D., McNaughton, L., Greig, M. (2018). The temporal pattern of recovery in eccentric hamstring strength post-soccer specific fatigue. *Res Sports Med*, *27* (3), 339–350.

Rhodes, D., Alexander, J., Greig, M. (2020b). The temporal pattern of recovery in eccentric strength – post localised fatigue. *J Health*, *4* (1), 1–15.

Roe, M., Malone, S., Delahunt, E., Collins, K., Gissane, C., Persson, U.M., Blake, C. (2018). Eccentric knee flexor strength profiles of 341 elite male academy and senior gaelic football players: Do body mass and previous hamstring injury impact performance? *Phys Ther Sport*, *31,* 68–74. DOI: 10.1016/j.ptsp.2018.01.006.

Sconce, E., Jones, P., Turner, E., Comfort, P., and Graham-Smith, P. (2015). The validity of the nordic hamstring lower as a field-based assessment of eccentric hamstring strength. *Journal of Sports Rehabilitation*, *24* (1), 13–20.

Sedliak, M., Haverinen, M., Hakkinen, K. (2011). Muscle strength, resting muscle tone and EMG activation in untrained men: Interaction effect of time of day and test order-related confounding factors. *J Sports Med Phys Fit*, *51* (4), 560–570.

Sherry, M.A., Best, T.M. (2004). A comparison of 2 rehabilitation programs in the treatment of acute hamstring strains. *J Orthop Sports Phys Ther*, *34* (3), 116–125.

Small, K., McNaughton, L.R., Greig, M., Lovell, R. (2009). The effects of multidirectional soccer-specific fatigue on markers of hamstring injury risk. *J Sci Med Sport*, *13* (1), 120–125.

Timmins, R.G., Bourne, M.N., Shield, A.J., Williams, M.D., Lorenzen, C., Opar, D.A. (2015). Short biceps femoris fascicles and eccentric knee flexor weakness increase the risk of hamstring injury in elite football (soccer): a prospective cohort study. *Br J Sports Med*, *50* (24), 1524–1535.

Tyler, T.F., Schmitt, B.M., Nicholas, S.J., McHugh, M.P. (2017). Rehabilitation after hamstring strain injury emphasising eccentric strengthening at long muscle lengths: Results of long term follow up. *J Sports Rehab*, *26* (2), 131–140.

Van Melick, N., Meddeler, B.M., Hoogeboom, T.J., Nijhuis-van der Sanden, M.W.G., van Cingel, R.H.E. (2017). How to determine leg dominance: The agreement between self-reported and observed performance in healthy adults. *PLoS ONE*, *12* (12), 1–9.

Vicens-Bordas, J., Esteve, E., Fort-Vanmeerhaeghe, A., Clausen, M.B., Bandholm T., Opar D., Shield A., Thorborg K. (2020). Eccentric hamstring strength is associated with age and duration of previous season hamstring injury in male soccer players. *Int J Sports Phys Ther*, *15* (2), 246–253.

Wiesinger, H.P., Gressenbauer, C., Kösters, A., Schardinger, M., Müller, E. (2020). Device and method matter: A critical evaluation of eccentric hamstring muscle strength assessments. *Scand J Med Sci Sports*, *30* (2), 217–226.

Wilhite, M.R., Cohen, E.R., Wilhite, S.C. (1992). Reliability of concentric and eccentric measurements of quadriceps performance using the KIN-COM dynamometer: The effect of testing order for three different speeds. *J Orthop Sports Phys Ther*, *15* (4), 175–182.

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REVIEWING AVAILABLE ONLINE PUBLICATIONS ON THE EFFECT OF DANCE ON THE PHYSICAL AND MENTAL HEALTH OF CHILDREN AND ADOLESCENTS

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Abstract The purpose of this research paper is to review the literature on dance and its impact on children and adolescents' physical health, physiology, psychology and quality of life, as well as its impact on their social behavior and social relationships. With this objective in mind, we carried out an extensive review of the existing literature in the following databases: MEDLINE, AMED, SCOPUS, ERIC, EMBASE and GOOGLE SCHOLAR. Based on this review, it appears that dancing may be a suitable activity that encourages and prompts people to adopt healthy behaviors. In particular, the literature shows that during dance activities performed by children and adolescents, there are significant benefits to a healthy development of the body, to the improvement of mental and emotional health, as well as to the improvement of their social behavior and social relations. In addition, according to the literature reviewed, even during the Covid-19 pandemic, dance seems to be an efficient means of inspiring active engagement in children and adolescents. A means which can be available beyond in-person teaching, whiles still offering all of the benefits of the subject matter at the same time.

Keywords benefits, dance, mental health, well-being, quality of life, fitness, children and adolescents

Introduction

Physical activity for children has significant benefits in health, which involve healthy growth and body development and prevention of obesity, but also the general protection of health during adulthood (World Health Organization, 2009; Janssen, Leblanc, 2010). Physical activity is a major factor that affects cardiovascular mortality, as well as, cardio-respiratory ability, fitness and obesity; it reduces the risk of developing a coronary heart disease, diabetes, stroke, some types of cancer and depression, while it increases neuromuscular coordination and improves self-esteem (Fox, 2000; Robinson et al., 2003; Nocon, Hiemann, Muller-Riemenschneider, Thalau, Roll, Willich, 2008; Robinson et al., 2008; World Health Organization, 2009; Theocharidou, Lykesas, Giosos, Chatzopoulos, Koutsouba, 2018).

According to a number of studies, dance is a pleasant physical activity that attracts both young and elderly participants. As a physical activity and a creative art form, dance is placed highly in the agenda of healthy living (Khan, 2000; Arts Council of England, 2004, 2006; Lykesas, Siskos, Zachariadou, 2010; Mavridis, Filippou, Rokka, Bousiou, Mavridis, 2004; Burkhardt, Brennan, 2012; Romero, 2012). It is well known that dance offers an active, different form of exercise that could have positive results in physical health, as well as, mental, and emotional well-being (World Health Organization, 2010). It is a means of expression and communication, which gives the individual a possibility to express freely, as well as, know oneself and the way to interact with others (Alricsson, Harms-Ringdahl, Eriksson, Werner, 2003; NDTA, 2004; Burgess, Grogan, Burwitz, 2006; Tsompanaki, Lykesas, 2020).

Many scientific studies report the physical and psychological benefits of dance, especially in the context of dance and movement therapy (Flores, 1995; Bennell et al., 2000; Blair, Cheng, Holder, 2001; Jeong et al., 2005; Quin, Frazer, Redding, 2007; Steinberg et al. 2008). Especially when it comes to children and young people, dance as an art form, is considered a «bridge for the mental health of children and adolescents», it can contribute to their cognitive and emotional development, which is related to the students' academic performance (Bennell et al., 2000; Minton, 2001; Akandere, Demir, 2011; Lykesas, Giosos, Theocharidou, Chatzopoulos, Koutsouba, 2018). Through dance, movement is transformed into a purposeful phrase of action that encompasses physicality, emotion, and cognition (Azevedo, Watson, Haighton, Adams, 2014; Mavropoulou, Barkoukis, Douka, Alexandris, 2018). According to researchers, engaging children and adolescents in dance and movement therapy programs improved their improvisation skills, their body control, balance, and coordination, as well as kinesthetic awareness, musical rhythmic skills, muscular strength, flexibility and stamina (Chatzopoulos, Doganis, Kollias, 2018; Chatzihidiroglou, Chatzopoulos, Lykesas, Doganis, 2018; Lykesas, Giosos, Douka, Bakirtzoglou, Chatzopoulos, 2019; Chatzopoulos, 2019; Kapodistria, Chatzopoulos, Chomoriti, Lykesas, Lola, 2021). In addition to those, dance also has a positive influence on the improvement of their social relationships, their self-perception, and, generally, their quality of life (Lykesas, Chatzopoulos, Koutsouba, Douka, Bakirtzoglou, 2020). Dance also contributes to the socialization of individuals who have been isolated by society but it can also help to prevent depression and violent behavior (Leste, Rust, 1990; Koshland, Wittaker, 2004; Jeong et al., 2006; Lobo, Winsler, 2006; Soares, Lucena, 2013;

Quinones, Gomez, Agudelo, Martínez, López, 2018). It is for all the aforementioned reasons that dance is indeed considered of crucial importance in the development of young people, and their creative, artistic, personal, and social skills (Bungay, Vella-Burrows, 2013). At this point, it is important to note that according to research, even under the circumstances of the Covid-19 pandemic which brought about novel practices of learning and teaching, children and adolescents still benefited from the positive impact of dancing, through their engagement with it. More specifically, the Covid-19 pandemic resulted in the dance teaching community having to utilize online lessons (Gingrasso, 2020; Tariao, Yang, 2021), and authors such as McGreevy-Nichols, Dooling-Cain (2020) and Coelho, Menon (2020) and Re (2021), carried out research which showed that online lessons are a safe way to keep learning uninterrupted, as they provide the same knowledge and the same benefits that in-person lessons do (Nancy, 2020; Yariv, Shalem-Zafari, Wengrower, Shahaf, Zylbertal, 2021).

As evident from the information outlined above, the purpose of this paper is to review the literature on dance and its impact on children and adolescents' physical health, physiology, psychology and quality of life, as well as its impact on their social behavior and social relationships.

Method

For this review of studies, a search in respect of health and quality of life was conducted in the following scientific databases: MEDLINE, AMED, SCOPUS, ERIC, EMBASE and GOOGLE SCHOLAR. The methodological quality was assessed using criteria based on the CRD hierarchy of evidence (Centre for Reviews and Dissemination (CRD) 2009). Studies were included as long as they reported effects of a dance intervention program in the physical and mental health of children and adolescents. Additionally, the studies involved refer strictly to children and adolescents. Only published research studies in English were taken into account and no research in the literature of other languages nor in unpublished works was conducted.

Results

From the database research 1,232 studies were found, from which seventy-two (72) were considered for potential selection based on their abstracts. After removing double studies, sixty (60) studies were considered optimal for full reading and evaluation. From these, twenty-nine (29) studies fulfilled the criteria and were selected to be included in this review. These twenty-nine (29) studies were divided into two categories: in the first category, fifteen (15) were selected and concerned physical health, and in the second, fourteen (14) were selected and concerned the psychosocial health of children and adolescents. The studies involved a wide range of lesson methodologies, as well as, various dance styles and they were clearly experimental. In addition, the study review included seven (7) research papers on engaging with dance during the Covid-19 pandemic.

Findings in body health through dance (fitness, health, obesity and neuromuscular control)

Fifteen (15) studies examined the importance of dance as an intervention program in the improvement of child and adolescent health and produced great results. Five of these studies concerned fitness and health (Blackman, Hunter, Hilyer, Harrison, 1988; Flores, 1995; Blair et al., 2001; Alricsson et al., 2003; Mavridis et al., 2004). In one of these, Flores (1995), designed an intervention program, Dance for Health, in order to provide Afroamerican and Spanish speaking children, aged 10–13 years, with a pleasant aerobic dance program to improve aerobic ability, helping students reduce weight and improve their attitude towards physical activity and fitness. The results showed great reduction of BMI (Body Mass Index) and significant improvement of their attitude towards their fitness. The study of Blair, Cheng, Holder (2001) showed the positive impact dance has for more active individuals on their fitness and longevity and their reduced risk of heart and cardiovascular diseases, strokes, and colorectal cancer. Blackman et al. (1988) implemented a 4-month long aerobic dance program for high school students, the results were positive in terms of BMI reduction, significant improvement of students' fitness, self-image, and self-esteem. In the study of Mavridis et al. (2004) 6 and 7 year-old first graders of a primary school followed an aerobic dance program that improved their fitness, as well as, their cardio-respiratory ability, strength, stamina, and flexibility. Alricsson et al. (2003) implemented a dance program in 12–15 year-old adolescent skiers, the results showed that participating in dance programs generally improved their fitness, speed, agility, joint mobility and they increased the flexion-extension of the thoracic spine and the lateral flexion of the spine.

A total of six (6) studies showed the positive impact of dance on obesity, BMI, and the percentage of body fat (Bennell et al., 2000; Robinson et al., 2003; Robinson et al., 2008; Steinberg et al., 2008; Romero, 2012; Azevedo et al., 2014). In his study, Romero (2012) addressed adolescent girls and boys of a Mexican-American origin that faced obesity and socialization problems. The implementation of a hip-hop and latin dance program showed that girls reported BMI reduction and better communication in their relationship, whereas boys only developed better social relationships. Also, a study by Azevedo et al. (2014) in terms of the impact Exergaming dance has on students aged 11–13 years, was characterized as a pioneer method to promote physical activity in the school environment. The results showed that the intervention had a significantly positive impact on weight, BMI, and the percentage of body fat. There was also improvement in some parameters of the quality of life that related to the students' psychological well-being and autonomy. The study of Bennell et al. (2000), showed that the participation of 8–11 year old girls in dance programs such as ballet, produced positive impact on their body density (BMD). The study of Steinberg et al. (2008) examined the body structure of girl dancers and non-dancers aged 8–16 years. They implemented a program with several dance styles, such as ballet, modern dance, and jazz, in order to evaluate if there were differences in BMI, height, and fat distribution between the two groups. The results showed that there were significant differences in terms of physical constitution and fat distribution while in terms of musculoskeletal development (height) there was no difference between dancers and non-dancers. Two studies by Robinson et al. (2003, 2008), researched if a therapy through expressive dance limited the time students watched TV and if it influenced body weight in 8–10 year old African-American girls. The intervention lasted twelve weeks and consisted of expressive dance lessons that were realised after school in a community Centre and 5 interventions of dance lessons which were realised at the participants' houses. All interventions produced satisfactory results. The girls of the intervention group showed reduction of their body mass increase and increasing after school physical activity, as well as, they reduced the time they watched TV, videos, and played videogames.

A limited number four (4) of studies concerned the effects of dance on sensorimotor coordination (neuromuscular control). According to Chatzopoulos (2019), Chatzihidiroglou et al. (2018) and Lykesas et al. (2019) dancing has positive effects on proprioception, balance, sensorimotor synchronization and maybe response time (Kapodistria et al., 2021) of young children.

Findings in mental health through dance (self-esteem, depression, social behavior and life satisfaction)

In this review fourteen research studies on psychological well-being were also included. In particular, the study of Quin et al. (2007) points out the benefits of dance in the physical and mental health of children. Moreover, it gives information on how creative dance improves children's physical activity and their psychological wellness and, therefore, it promotes their health. It also shows that active young people are more likely to stay active in their adulthood, and that dance is a medium with great impact on the creation of a life-long healthier and more active lifestyle. In this study, children aged 11–14 years participated in a 10-week long program that researched the students' attitude towards dance. Both in boys and girls, there was an increase in all factors of fitness, as well as, in psychological fluctuations, self-esteem, internal motivation, participation for pleasure. Mavropoulou et al. (2018) examined the effect of different types of dance on subjective vitality of 252 primary school students. They were divided into three groups: a) the first group included modern, aerobic, hip hop, zumba, and expressive dance, b) the second group included traditional dance and c) third group, volleyball, basketball and football. The results showed that the different types of dance along with the traditional dance managed to keep the vitality of the students at a high level. On the contrary, the control group showed a significant reduction in vitality levels. Bungay, Vella-Burrows (2013) examined the impact creative dance has on the health and well-being of adolescent students aged 11–18 years. Upon the implementation of the program, it was evidenced that creative dance has a positive impact on changing the behavior among children, their self-confidence, their self-esteem, the levels of knowledge, and physical activity. The study of Leste, Rust (1990) with the implementation of contemporary dance in a group of adolescents showed positive results in the significant reduction of stress and improvement of self-esteem. The study of Burgess et al. (2006) researched the impact of aerobic dance on 13–14 year old girls with bad body posture and poor self-perception. The results showed significant improvements in their body image, self-esteem, and self-perception. Minton (2001) in her study states that the participation of high school girls and boys in aerobic dance lessons has a positive impact on their self-esteem and self-image. Furthermore, the study of Lykesas et al. (2010) showed that a greek traditional dance program addressed to high school students improved greatly pleasure, communication, respect, and collaboration among students. The research by Lykesas et al. (2020) evaluated the impact of a greek traditional dance teaching program on improving the classroom environment and increasing the students' satisfaction in the lesson of Physical Education (PE). The results of this program were positive, the students who were taught greek traditional dances showed greater satisfaction in the PE lesson, as well as a tendency to provide a caring environment and change of behavior in their classroom. Additionally, the results stated by Lobo, Winsler (2006) regarding an eight week long educational program on creative dance in preschool-age children, showed great progress in social ability and improvement in their behavior towards other students, as well as, towards teachers and parents. The research by Tsompanaki, Lykesas (2020) examined the impact of community dance on children aged 4–7 years, regarding the improvement of social inclusion in a team, as well as, the collaboration among students. The findings of this research showed that the program had positive impact on social relationships, communication, and collaboration among students.

The aforementioned positive effects of dance on the improvement of social skills, corroborate research which demonstrates a decline in incidents of aggressive behavior, and the adoption of healthier behaviors through dance intervention programs. Four studies in particular investigated the impact of dance on social skills, the improvement of social relationships, depression, and psychological distress of the students (Koshland, Wittaker, 2004; Jeong et al., 2005; Soares, Lucena, 2013; Quinones et al., 2018;. The study by Koshland, Wittaker (2004) investigated the decrease of incidents of aggression and the improvement of relationships through a program of creative dance in primary school students. The results showed that educators observed great changes in the students' perspectives and emotions regarding social behavior. They also showed improvement in their relations, inside the classrooms. The study by Jeong at al. (2005) examined the participation of adolescents with mild depression (average age of 16 years), in a Dance Movement Therapy program (DMT) through expressive dance. The results showed that all levels of the psychological discomfort scale were greatly reduced. Furthermore, the concentration of serotonine in plasma was increased, while dopamine concentration was decreased. These results denote that DMT may stabilize the sympathetic nervous system. Therefore, DMT can prove to be effective in the improvement of psychological discomfort in adolescents with mild depression. In terms of psychological balance, an increase in self-confidence, development of expressiveness, love for the activity, and, above all, sense of justice were observed. Soares, Lucena (2013) examined the role of dancing as a psycho-social tool in a group of fifty-five students, ages 6–11 years old who lived in unsafe socio-economic and school environments with incidents of bullying. The program lasted for a school year and utilised movement games as well as types of dances such as hip- hop, modern jazz, traditional folk dances and international dances. The results showed that students developed a positive attitude towards accepting feedback, respecting the rules, autonomy and collaboration, as well as improvement of the relationships among them.

The authors Quinones, Gomez, Agudelo, Martínez, López, (2018) implemented an intervention consisting of a 120-h training program in dance movement strategies in five violence-affected municipalities in Colombia. The aim of the intervention was to assess any possible changes in the participants' states of mindfulness, bodily connection, emotional intelligence, somatic complaints, aggressive reaction, empathy, agency, and subjective emotional experience. The results showed significant changes in mindfulness, bodily connection, emotional intelligence and regulation, somatic complaints, aggressive reaction, agency, perspective taking, sleep and appetite.

Research on dance during the Covid-19 Pandemic

Since the Covid-19 pandemic has brought about radical changes in the daily lives of citizens, there is research that shows that it is possible to engage in dance beyond the scope of in-person teaching (Re, 2021). The Covid-19 pandemic has greatly affected education in general and dance education in particular (Tariao, Yang, 2021). Dance education has now shifted towards the internet. Children and adolescents dance and enjoy dance online (Nancy, 2020; McGreevy-Nichols, Dooling-Cain, 2020). However, for some students, there are some issues which arise such as space, privacy and internet access. With this in mind, teachers and students have the opportunity to re-evaluate their pedagogical and learning strategies (Gingrasso, 2020). Since the dancing activity does not require special equipment and facilities to exercise, according to research, online dance lessons have been a legitimate alternative form of physical activity which upholds all the positive effects of dance on physical and mental health (Coelho, Menon, 2020; Yariv et al. 2021). In particular, it has been proved to be effective in reducing sedentary behaviors and stress, and in enhancing daily physical activity and the immune system (Coelho, Menon, 2020).

All studies converge on the fact that online courses are just as safe to keep learning uninterrupted, providing the same knowledge and also the same benefits as in-person courses do (Nancy, 2020; Gingrasso, 2020; Coelho, Menon, 2020; McGreevy-Nichols, Dooling-Cain, 2020; Re, 2021; Yariv et al. 2021).

Discussion

Dance is an elaborate motor tool that helps individuals develop social skills and interests so as to enjoy a stable social life (Lobo, Winsler, 2006). The literature review demonstrates the benefits of dance for young people and adolescents in particular, and in many different areas. More specifically, the results of the review showed that there are significant benefits in health and healthy growth and body development, as well as, prevention of obesity and heart condition. Interventions that involve different dance styles and research protocols benefit balance and rhythm, neuromuscular coordination, and fitness, but also, improve psychological health, boost self-esteem, have positive impact on depression, develop collaboration skills and effectiveness in the educational process, as well as, social relationships (Blackman et al., 1988; Leste, Rust, 1990; Bennell et al., 2000; Minton, 2001; Alricsson et.al., 2003; Mavridis et al., 2004; Quin et al., 2007; Chatzihidiroglou et al., 2018; Lykesas et al., 2018; Chatzopoulos, 2019; Kapodistria et al., 2021).

In addition, research shows that dance can reduce incidents of aggressive behavior among children and improve their social behavior (Koshland et al., 2004; Jeong et al., 2005; Soares, Lucena, 2013; Quinones et al., 2018). This fact is particularly encouraging in terms of preventing and dealing with adverse incidents and bullying, which has been prominent worldwide (Craig, Peplerband, Blais, 2007; Morres, Galanis, Hatzigeorgiadis, Androutsos, Theodorakis, 2021).

Apparently dance can be a way to attract young people in order to engage them in physical activity and possibly become an alternative form of exercise for children and young people that usually dislike traditional forms of exercise (Robinson et al., 2003, 2008). This may be attributed to the many forms of dance and the range of choices that children and adolescents have at their disposal, to choose the type that suits them best and engage with it, or it may be due to how the subject matter itself is taught. Because of its pleasant and social nature (Wanless, 2004; Quin et al., 2007), dance provides children and adolescents with a different form of kinetics than other forms of exercise do. Through movement and music, children and adolescents have the opportunity to express themselves in distinctive ways, liberating their minds, bodies and emotions (Caf, Kroflic, Tancig, 1997; Sothern, Loftin, Suskind, Udall, Blecker, 1999; Tsompanaki, Lykesas, 2020).

According to the literature review, dancing can improve both physical and mental health (Khan, 2000; Janssen, Leblanc, 2010). Therefore, considering that physical movement is a significant public health issue (Carter, 1984), then the claim that dance could contribute to meeting basic health needs can very well be valid. For this reason, it is important to note that dancing as a motor activity has been an alternative form of exercise even during the Covid-19 pandemic. As is well known, the Covid-19 pandemic has influenced education worldwide in significant ways by diversifying the way the educational process takes place; by adopting innovative teaching methods such as online courses, which is a safe way to keep the learning process uninterrupted (McGreevy-Nichols, Dool-Cain, 2020; Nancy, 2020; Coelho, Menon, 2020; Re, 2021). Relevant research has shown that children can engage in dance through the use of the internet and in fact gain the same positive effects of dance on physical and mental health (Gingrasso, 2020; Yanuartuti, Handayaningrum, 2020) as in-person teaching provides (Yariv et al., 2021).

Finally, it should be noted that this research is subject to methodological limitations. These limitations pertain to the different methodological designs, regarding the ages of the participants, the different types of dance, the teaching methods and the duration of the interventions, which make it difficult to compare the results of the research. However, despite the above limitations, all research demonstrates the importance of dance in the physical and mental health of children and adolescents. For this reason, it is recommended that further research should be carried out on the effect of teaching methods and the comparability of different forms of dance, in order to design effective interventions and improve dance teaching to further reap the benefits of dance.

Conclusion

The results of the above literature review show that dance, as a motor activity, but also as a pedagogical tool, contributes to the healthy development of the body, to the improvement of mental and emotional health, as well as to the improvement of social behavior and social relations of children and of adolescents, in a positive way. This is important, as dancing can have a beneficial impact and lead to a healthier lifestyle, not only during childhood and adolescence, but also throughout one's life.

References

Akandere, M., Demir, B. (2011). The effect of dance over depression. *Collegium antropologicum, 35* (3), 651–656.

Alricsson, M., Harms-Ringdahl, K., Eriksson, K., Werner, S. (2004). The effect of dance training on joint mobility, muscle flexibility, speed and agility in young cross-country skiers – a prospective controlled intervention study. *Scandinavian Journal of Medicine & Science in Sports*, *13* (4), 237–243.

Arts Council of England (2004). Artists working in partnership with schools; Quality indicators and advice for planning, commissioning and delivery.

Arts Council England (2006). Department of Health and the Department for Culture, Media and Sport, Dance and health: The benefits for people of all ages.

Azevedo, L.B., Watson, D.B., Haighton, C., Adams, J. (2014). The effect of dance mat exergaming systems on physical activity and health–related outcomes in secondary schools: results from a natural experiment. *BioMed Central Public Health*, *14* (1), 1–13.

Bennell, K., Khan, K., Matthews, B., Cook, E., Holzer, K., Mckay, H., Wark, J. (2000). Activity-associated differences in bone mineral are evident before puberty: A cross-sectional study of 130 female novice dancers and controls. *Pediatric Exercise Science*, *12* (4), 371–381.

Blackman, L., Hunter, G., Hilyer, J., Harrison, P. (1998). The Effects of Dance Team Participation on Female Adolescent Physical Fitness and Self Concept. *Adolescence*, *23* (90), 437–448.

Blair, S.N., Cheng, Y., Holder, S. (2001). Is physical activity or physical fitness more important in defining health related benefits? *Medicine and Science in Sport and Exercise*, *33* (6), 379–399.

Block, A. (1997). *I'm only bleeding: Education as the practice of social violence against the child.* New York: Peter Lang.

Bungay, H., Vella-Burrows, T. (2013). The effects of participating in creative activities on the health and well-being of children and young people: a rapid review of the literature. *Perspectives in Public Health, 133* (1), 44–52.

Burgess, G., Grogan, S., Burwitz, L. (2006). Effects of a 6-week aerobic dance intervention on body image and physical self-perceptions in adolescent girls. *Body Image, 3* (1), 57–66.

Burkhardt, J., Brennan, C. (2012). The effects of recreational dance interventions on the health and well-being of children and young people: A systematic review. *Arts & Health: An International Journal of Research, Policy and Practice*, *4* (2), 148–161.

Caf, B., Kroflic, B., Tancig, S. (1997). Activation of hypoactive children with creative movement and dance in primary school. *The Arts in Psychotherapy*, *24* (4), 355–365.

Carter, L. (1984). The state of dance in education: Past and present. *Theory Into Practice*, *23* (4), 293–299.

Centre for Reviews and Dissemination (CRD) (2009). In: *Systematic Reviews: CRD's guidance for undertaking reviews in health care.* York: University of York.

Chatzihidiroglou, P., Chatzopoulos, D., Lykesas, G., Doganis, G. (2018). Dancing Effects on Preschoolers' Sensorimotor Synchronization, Balance and Movement Reaction. *Perceptual and Motor Skills*, *125* (3), 463–477.

Chatzopoulos, D. (2019). Effects of Ballet Training on Proprioception, Balance, and Rhythmic Synchronization of Young Children. *Journal of Exercise Physiology online*, *22* (2), 26–37.

Chatzopoulos, D., Doganis, G., Kollias, I. (2018). Effects of creative Dance on Proprioception, Rhythm and Balance of preschool Children. *Early Child Development and Care*, *189* (12), 1943–1953.

Coelho, C., Menon, S. (2020). Online Dance Training in a Social Distancing Environment: Examining Preferences of Latin and Ballroom Dancers. *Dance Education in Practice*, *6* (4), 23–29.

Craig, W., Peplerband, D., Blais, J. (2007). Responding to Bullying What Works? *School Psychology International*, *28* (4), 465–477.

Flores, R. (1995). Dance for health: Improving fitness in African American and Hispanic adolescents. *Public Health Reports*, *110* (2), 189–193.

Fox, K. (2000). *Physical activity and psychological well-being.* London: Routledge.

Gingrasso, S. (2020). Practical Resources for Dance Educators! Choreographing Our Way Through COVID-19. *Dance Education in Practice*, *6* (3), 27–31.

Janssen, I., Leblanc, A. (2010). Systematic Review of the Health Benefits of Physical Activity in School-Aged Children and Youth. *International Journal of Behavioural Nutrition and Physical Activity*, *7* (40), 1–16.

Jeong, Y.J., Hong, S.C., Lee, M.S., Park, M.C., Kim, Y.K., Suh, C.M. (2005). Dance movement therapy improves emotional responses and modulates neurohormones in adolescents with mild depression, *International Journal of Neuroscience*, *115* (12), 1711–1720.

Kapodistria, L., Chatzopoulos, D., Chomoriti, K., Lykesas, G., Lola, A. (2021). Effects of a Greek Traditional Dance Programme on Sensorimotor Synchronization and Auditory Reaction Time of Young Children. *International Electronic Journal of Elementary Education*, *14* (1), 1–8.

Khan, K.M. (2000). Does childhood and adolescence provide a unique opportunity for exercise to strengthen the skeleton? *Journal of Science and Medicine in Sport*, *3* (2), 150–164.

Koshland, L., Wittaker, J. (2004). PEACE Through Dance/Movement: Evaluating a Violence Prevention Program. *American Journal of Dance Therapy*, *26* (2), 69–90.

Leste, A., Rust, J. (1990). Effects of dance on anxiety. *American Journal of Dance Therapy*, *12*, 19–25.

Lobo, B.Y., Winsler, A. (2006). The Effects of a Creative Dance and Movement Program on the Social Competence of Head Start Preschoolers. *Social Development*, *15* (3), 501–519.

Lykesas, G., Siskos, V., Zachariadou, Z. (2010). The Effect of a Greek Traditional Dance Teaching Programme in the Improvement of High School Students Attitude in the Classroom and their Increased Satisfaction of in Physical Education Lesson. *Science of Dance*, *5*, 1–36.

Lykesas, G., Chatzopoulos, D., Koutsouba, M., Douka, S., Bakirtzoglou, P. (2020). Braindance: An Innovative Program for the Teaching of Traditional and Creative Dance in the School Subject of Physical Education. *Sport Science*, *13* (1), 99–107.

Lykesas, G., Giosos, I., Theocharidou, O., Chatzopoulos, D., Koutsouba, M. (2018). The Effect of a Traditional Dance Program on the Health-Related Quality of Life as Perceived by Primary School Students. *Journal of Education and Training Studies*, *6* (1), 97–104.

Lykesas, G., Giosos, I., Douka, S., Bakirtzoglou, P., Chatzopoulos, D. (2019). Epistemological Assumptions about the Relationship between Quality of Life and Dance: A Different Approach. *Sport Science*, *12* (1), 77–82.

MacDonald, C.J. (1991). Creative dance in elementary schools: A theoretical and practical justification. *Canadian Journal of Education*, *16* (4), 434–441.

Mavridis, G., Filippou, F., Rokka, S., Bousiou, St., Mavridis, K. (2004). The effect of a health-related aerobic dance program on elementary school children. *Journal of Human Movement Studies*, *47*, 337–349.

Mavropoulou, A., Barkoukis, B., Douka, S., Alexandris, K. (2018). The effect of a dance program on the subjective vitality of primary school students. *Hellenic Journal of Physical Education & Sport Science,* 40–44.

McGreevy-Nichols, S., Dooling-Cain, S. (2020). Advocating for Your Program of Covid-19. *Journal of Dance Education*, *20* (4), 245–246.

Minton, C.S. (2001). Assessment of high school dance students' self-esteem. *Journal of Dance Education*, *1* (2), 63–73.

Morres, I., Galanis, E., Hatzigeorgiadis, A., Androutsos, O., Theodorakis, Y. (2021). Physical Activity, Sedentariness, Eating Behaviour and Well-Being during a COVID-19 Lockdown Period in Greek Adolescents. *Nutrients*, *13* (5), 1–12.

Nancy. (2020). Beating the Covid-19 blues with dance and songs: women's group work in the times of a pandemic. *Social Work with Groups*.

National Dance Teachers Association (NDTA). (2004). In *Maximizing Opportunity*, *Policy Paper.*

Nocon, M., Hiemann, T., Muller-Riemenschneider, F., Thalau, F., Roll, S., Willich, S.N. (2008). Association of physical activity with all-cause and cardiovascular mortality: A systematic review and meta-analysis. *European Journal of Cardiovascular Prevention and Rehabilitation*, *15* (3), 239–246.

Quin, E., Frazer, L., Redding, E. (2007). The Health Benefits of Creative Dance: improving children's physical and psychological wellbeing. *Education and Health*, *25* (2), 31–33.

Quinones, N., Gomez, Y., Agudelo, M.D., Martínez, G., López, A.M. (2018). Dance movement strategies training to help rebuild social capital in Colombia. *Journal of Mental Health and Psychosocial Support in Conflict Affected Areas*, *16* (2), 110–118.

Re, M. (2021). Isolated systems towards a dancing constellation: coping with the Covid-19 lockdown through a pilot dance movement therapy tele-intervention. *Body, Movement and Dance in Psychotherapy*, *16* (1), 9–18.

Robinson, T.N., Killen, J.D., Kraemer, H.C., Wilson, D.M., Matheson, D.M., Haskell, W.L., Pruitt, L.A., Powell, T.M., Owens, A.S., Thompson, N.S., Flint-Moore, N.M., Davis, G.J., Emig, K.A., Brown, R.T., Rochon, J., Green, S., Varady, A. (2003). Dance and reducing television viewing to prevent weight gain in African-American girls: the Stanford GEMS pilot study. *Ethnicity & Disease*, *13* (1), 65–77.

Robinson, T., Kraemer, H., Matheson, D., Obarzanek, E., Wilson, D., Haskell, W., Pruitt, L., Thompson, N., Haydel, K., Fujimoto, M., Varady, A., McCarthy, S., Watanabe, C., Killen, J. (2008). Stanford GEMS phase 2 obesity prevention trial for low-income African-American girls: Design and sample baseline characteristics. *Contemporary Clinical Trials, 29*, 56–69.

Romero, A.J. (2012). A pilot test of the Latin active hip hop intervention to increase physical activity among low-income Mexican-American adolescents. *Journal of Health Promotion*, *26* (4), 208–211.

Soares, D.S.V., Lucena, S.F.V.B. (2013). The contribution of dancing in the socio-emotional development of children at extracurricular activities in a Portuguese primary school. *Journal of Music and Dance*, *3* (1), 6–11.

Sothern, M.S., Loftin, M., Suskind, R.M., Udall, J.N., Blecker, U. (1999). The health benefits of physical activity in children and adolescents: implications for chronic disease prevention. *European Journal of Pediatrics*, *158* (4), 271–274.

Steinberg, N., Siev-Ner, I., Peleg, S., Dar, G., Masharawi, Y., Hershkovitz, I. (2008). Growth and development of female dancers aged 8–16 years. *American Journal of Human Biology*, 299–307.

Tariao, F.C., Yang, J.M.J. (2021). Delivering Face-to-Face Dance Classes in Singapore during the COVID-19 Pandemic. *Journal of Dance Education*, 1–12.

Theocharidou, O., Lykesas, G., Giosos, I., Chatzopoulos D., Koutsouba, M. (2018). The Positive Effects of a Combined Progr,am of Creative Dance and BrainDance on Health-Related Quality of Life as Perceived by Primary School Students. *Physical Culture and Sport. Studies and Research*, *79* (1), 42–52.

Tsompanaki, E., Lykesas, G. (2020). Effect of Community Dance on Children's Socialization in Creative Activities Centers. *Sport Science*, *14* (1), 65–71.

Wanless, D. (2004). *Securing good health for the whole population: Final report.* London: HM Treasury.

World Health Organization (2004). In *Global Strategy on Diet, Physical Activity and Health.* Geneva: World Health Organization.

World Health Organization (2009). In *Global Health Risks: Mortality and burden of disease attributable to selected major risks.* Geneva: World Health Organization.

World Health Organization (2010). The Global Recommendations on Physical Activity for Health. Retrieved from https://www.who.int/publications/i/item/9789241599979.

Yanuartuti, S., Handayaningrum, W. (2020). Dancing as an Expressive Media in the Middle of Pandemic. *491*, 770–778. Conference: International Joint Conference on Arts and Humanities.

Yariv, A., Shalem-Zafari, Y., Wengrower, H., Shahaf, N., Zylbertal, D. (2021). Reflections on individual webcam dance/movement therapy (DMT) for adults. *Body, Movement and Dance in Psychotherap*, *16* (1), 56–63.

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THE USE OF DIETARY AND PROTEIN SUPPLEMENTS BY WOMEN ATTENDING FITNESS CLUBS ON A RECREATIONAL BASIS AND AN ANALYSIS OF THE FACTORS INFLUENCING THEIR CONSUMPTION

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Abstract The aim of the study was to assess the dietary supplements used by amateur sportswomen training in fitness clubs (F – Fitness) compared to women who do not train (C – Control). Methods. 248 women aged 16 to 31 years (F: 120, C: 128) participated in the study. Results. In group F, 60.00% of women used protein products, 40.83% other dietary supplements, most often: creatine 17.50%, vitamin complexes 10.00%, vitamin D 10.00%, branched chain amino acids 7.50%, fish oil/omega acids 7.50%. A positive predictor of the use of protein supplements was the consumption of vegetables (B: 1.26, 95% CIs: 1.13–11.01). Total supplement use: age (B: 0.27, 95% CIs: 1.09–1.59), number of months of training (B: 0.59, 95% CIs: 1.15–2.81), following the advice of a dietitian (B: 1.50, 95% CIs: 1.45–13.87) and calorie counting (B: 1.54, 95% CIs: 1.49–14.53). Positive predictors of creatine use were: age (B: 0.54, 95% CIs: 1.21–2.42) and calorie count (B: 2.09, 95% CIs: 1.35–48.32). Conclusions. Supplements were more often used by women who were older, who did long training sessions, who were counting calories and those who were seeing a dietitian. Creatine was used more frequently by older women and women counting calories.

Keywords diatery supplements, amatour women, fitness clubs

Introduction

Dietary supplements are products for special nutritional purposes designed to supplement deficiencies in certain nutrients in the daily diet. They therefore do not replace a properly balanced diet and are not a substitute for it. The purpose of taking supplements is to correct a deficiency of nutrients by delivering to the body, in a concentrated form, the nutrients that are lacking in the daily diet. They help in the appropriate fulfilment of the demand for energy and nutrients, thus preventing diseases resulting from deficiencies, e.g., of certain vitamins. They contain “dietary components”, which can be: vitamins, minerals, herbs or other botanical ingredients, amino acids, or substances such as enzymes. Dietary supplements are bioactive substances which come in many different forms, such as: tablets, capsules, liquids, powders or bars and which are a selected source of nutrients or other substances with a nutritional or physiological effect (Maughan et al., 2018; Kerksick et al., 2018; Harty, Zabriskie, Erickson, Molling, Kerksick, Jagim, 2018; Vitale, Getzin, 2019).

The use of dietary supplements is now more and more widespread both in the world of professional sports and among people practising sports recreationally. They play a significant role in supplementing the nutrition of athletes, who need to take particular care in consuming the correct amount of carbohydrates, proteins, and other nutrients necessary for the proper functioning of the body. While most dietary supplements available to athletes and their potential role in increasing body performance are not supported by scientific research, supplementing with these nutrients can help broaden the daily diet to optimise sports performance (Savino et al. 2019; Peeling, Castell, Derave, de Hon, Burke, 2019; Housman, Dorman, 2008; Ward et al., 2019).

All substances, whose effect on the body is scientifically proven in terms of supporting performance in sports, are called ergogenic aids (Santesteban Moriones, Ibáñez Santos, 2017). Safety, effectiveness, classification and subdivision of individual dietary supplements used to improve sports performance, as well as recommendations for their proper use, were determined by the International Olympic Committee (IOC) (Maughan et al., 2018) and the International Society of Sports Nutrition (Kerksick et al., 2018). Controversy surrounds the ergogenic value of various supplements for athletes. Some experts believe that they should only be used when scientific research clearly shows that they have a significant effect on increasing performance in sport. Others, on the other hand, believe that if the supplement helps prepare the athlete for training or accelerates post-workout regeneration and training adaptations, it should be used and considered an ergogenic aid. Due to the fact that there is still no scientific evidence for the effectiveness of many dietary supplements available on the market, their use should be under the supervision of dietitians or sports medicine physicians (Maughan et al., 2018; Kerksick et al., 2018; Ward et al., 2019).

Supplementation in sport is aimed at achieving a specific effect related to sport or competition, mainly by increasing the body's efficiency and accelerating its regeneration. Furthermore, it aims to hydrate the athlete's body and replenish the electrolytes lost in sweat during training, to provide carbohydrates before, during and after exercise, or to supplement proteins and provide the amino acids necessary for post-exercise adaptations. Permitted supplements used in sports can be divided into those that increase muscle mass, accelerate fat burning, increase the body's immunity, regenerate joints, and improve psychophysical fitness. Supplements also aim to stimulate the immune system, reduce oxidative stress, and maintain overall health (Savino et al., 2019; Peeling et al., 2019; Housman, Dorman, 2008; Ward et al., 2019; Rawson, Miles, Larson-Meyer, 2018).

A large percentage of dietary supplements are also the so-called meal replacement (MRP) and ready-to-drink (RTD) supplements, as well as energy bars and gels (Maughan et al., 2018; Kerksick et al., 2018; Gavrilova et al., 2020). Depending on the manufacturer, they differ in the amount of carbohydrates, fats, and proteins, the mineral and vitamin content, and the specific nature of their operation. They are either used to promote muscle gain or to increase weight loss or enhance the body's performance (Maughan et al., 2018; Kerksick et al., 2018; Gavrilova et al., 2020; Burke, Hawley, 2018; Baume, Hellemans, Saugy, 2007). They are believed to be both a convenient and a good way to satisfy energy deficiencies as they arise, when it is not possible to eat a balanced meal. They are definitely a good alternative to fast food or other low-nutritional foods (Burke, Hawley, 2018). However, they should be used with caution – to supplement the dietary needs with macronutrients when they arise, and used as a substitute for a balanced diet (Brożyna, Tkaczyk, Rutkowska, 2019).

Athletes use supplements mainly because they believe that they have a beneficial effect on increasing the body's performance (Krejpcio, Skwarek, Hyżyk, Dyba, 2011; Mujika, Burke, 2010). Good nutritional practices, which form part of a training program and satisfy the ongoing energy needs of the body is one of the ways of adapting the body to increased physical exertion. Athletes who eat a properly balanced diet, thus providing the body with the correct amounts of calories, proteins, carbohydrates, and fats in order to prevent vitamin deficiencies, as well as the necessary macro- and microelements, can certainly increase the body's adaptation to the training loads imposed on it (Burke, Hawley, 2018).

Each person who practices sports should bear in mind that proper nutrition and proper planning of meals throughout the day, together, are one of the key elements of the training program that determine the possibility of achieving satisfactory results in sports. It is obvious that in the case of sportspeople, the demand for energy and nutrients increases, which also results from the loss of water, electrolytes, and minerals, as well as the necessary biological renewal of the body. An incorrect diet and lack of nutrients when the body needs them lead to a negative energy balance and can inevitably contribute to a loss of muscle mass and strength, increased trauma, and fatigue (overtraining) of the body (Maughan, Shirreffs, 2018; Jîtcă, Tero-Vescan, Miklos, Vari, Ősz, 2018).

In order to meet the expectations of modern athletes, dietary supplements, especially those intended for athletes, are often advocated. Depending on the sports discipline, these supplements are designed to provide certain necessary nutrients, including biologically active substances. The nutritional needs of individual groups of athletes are varied, depending on the duration and intensity of training and the nature of the sports discipline (speed, endurance). Therefore, there is no single method of nutrition or supplementation recommended for all athletes and the individual needs of a given person should always be taken into account (Jîtcă et al., 2018; Martinovic et al., 2021; Kotnik, Jurak, Starc, Puc, Golja, 2018).

Unfortunately, unlike professionals, amateurs often do not know enough about the correct rules of nutrition in sport or about suitable supplementation, and very often they use supplements in an ill-considered manner, for example following the advice of friends or the advertising of specific products on the Internet. It is believed that people who train recreationally, eg 3–4 times a week for 30–60 minutes, can usually meet their own macronutrient needs, that is, 45–55% carbohydrates (3–5 g/kg/day), 10–15% protein (0.8–1.0 g/kg/day) and 25–35% fat (0.5–1.5 g/kg/day) by consuming a normal daily diet (Maughan et al., 2018; Kerksick et al., 2018).

Certainly, the level of knowledge about nutrition and supplementation in sport for many competitors and sports enthusiasts may be inadequate (Sparks, Janse van Rensburg, Fletcher, Jansen van Rensburg, 2018; Andrews, Wojcik, Boyd, Bowers, 2016). They often do not have the financial resources to discuss their decisions with a professional dietitian or personal trainer who are able to estimate the additional nutritional need based on a general training program daily diet. Failure to provide the body with the necessary energy substrates leads to the occurrence of physical and mental symptoms of overtraining.

The aim of the research was to assess the dietary supplements used by sportswomen training recreationally in fitness clubs and to examine the factors influencing the use of protein supplements, general supplements and creatine.

Matrials and methods

Participants

The study involved 248 women. This comprised 120 women who attended a fitness club in Kraków in the Malopolska Voivodeship in Poland, hereinafter referred to as the Fitness Group, and 128 women who declared that they did not participate in any sport and did not exercise in fitness clubs – this was the Control Group. The Control Group consisted mainly of students of physiotherapy from one of the universities in Krakow and other women from among their families and friends. Most of the respondents from both groups lived in Kraków and its vicinity, in the Małopolska.

The inclusion criteria for the Fitness Group were regular exercise in fitness clubs, at least 1–2 hours a week, and for the Control Group it was declaring a lack of regular physical activity. The criteria for exclusion for both groups was the lack of a correctly completed questionnaire.

Participation in the research was voluntary and anonymous in accordance with the Declaration of Helsinki. The research protocol has been reviewed and approved by the Bioethical Committee of the Andrzej Frycz Modrzewski Kraków University (Permission number KBKA/93/O/2020).

Questionnaire

The research was conducted in spring and summer 2020 using the authors' own questionnaire. It is known that the level of physical activity varies throughout the year, usually higher in spring and summer. In the questionnaire, all the women were asked about the dietary supplements they used. Furthermore, the Fitness Group was asked about the time and type of training, sources of knowledge about dietary supplements that should be used in sports. The survey was conducted online using the Google Forms application. The Control Group questionnaire was slightly modified, and detailed questions about the time and type of training were removed.

Statistical Analysis

The statistical program in which the analysis was carried out was IBM Corp. Released 2020, IBM SPSS Statistics for Windows (Version 27.0. Armonk, NY: IBM Corp). The distribution of data was assessed using the Shapiro-Wilk test. The women's age and BMI were compared using the Mann-Whitney U test. The use of supplements in the Fitness Group and in the physically inactive group was compared using the Chi-Square test. Then an examination of the factors influencing the use of protein supplements and general supplements was performed excluding protein supplements and creatine. Creatine is the most frequently mentioned dietary supplement in the Fitness Group. At the outset, an analysis of the correlation of these components with age, BMI, time and type of training, sources of knowledge about nutrition and nutritional behaviours using the rho Spearman or phi coefficient was carried out. Next, a multiple logistic regression analysis was performed with selected predictors. The results of $p < 0.05$ were considered statistically significant.

Results

The age of the women in the Fitness Group ranged from 16 to 31 years (mean ± standard deviation: 21.5 ±2.9 years) with a Body Mass Index (BMI) of 16.3 to 34.1 (21.9 ±3.0), while in the Control Group the age of the women ranged from 17 to 31 years (mean ± standard deviation: 22.0 ±3.8 years), with a BMI of 15.8 to 37.2 (22.4 ±4.5). There were no statistically significant differences between the Fitness and Control Groups in terms of age (p = 0.177) and BMI (p = 0.268).

Women who trained in fitness clubs consumed protein products more often than the Control Group (Table 1). It was also noted that the percentage of women in the Fitness Group who used dietary supplements, other than protein products, was higher than the percentage of women in the Control Group. However, this difference did not reach statistical significance (Fitness vs Control; 40.83% vs 30.47%; p = 0.088). The most frequently used dietary supplements within the Fitness Group were: creatine, vitamin complexes, vitamin D, Branch-Chain Amino Acids (BCAA) and fish oil/omega acids.

Creatine, BCAA, vitamin complexes, fish oil/omega acids were taken significantly more often in the Fitness Group when compared to the Control Group. There was also a trend at the level of p = 0.072 for more frequent use of thermogenics, L-Carnitine and Ashwagandha by the women who were training. In the Control Group, vitamin A and iron supplements were used more often than in the Fitness Group.

Table 1. The use of protein products and other supplements in the Fitness Group and the Control Group

	Control		Fitness		chi^2	p
	n	%	n	%		
1	2	3	4	5	6	7
Protein products	0	0.00	72	60.00	108.22	<0.001
Dietary supplements	39	30.47	49	40.83	3.57	0.088
Creatine	0	0.00	21	17.50	24.47	<0.001
Vitamin Complex	4	3.13	12	10.00	4.85	0.028
Vitamin D	19	14.84	12	10.00	1.33	0.251
BCAA	0	0.00	9	7.50	9.96	0.002
Fish oil/Omega acids	2	1.56	9	7.50	5.15	0.023
B-group vitamins	8	6.25	4	3.33	1.14	0.287
Thermogenics	0	0.00	3	2.50	3.24	0.072
L-Carnitine	0	0.00	3	2.50	3.24	0.072
Ashwagandha	0	0.00	3	2.50	3.24	0.072
Collagen	1	0.78	3	2.50	1.15	0.285
Vitamin C	8	6.25	3	2.50	2.05	0.153
Vitamin K	1	0.78	3	2.50	1.15	0.285
Magnesium	7	5.47	3	2.50	1.41	0.237
Zinc	1	0.78	2	1.67	0.41	0.526
Probiotics	0	0.00	2	1.67	1.89	0.171
Caffeine	0	0.00	2	1.67	1.89	0.171
Vitamin A	7	5.47	1	0.83	4.26	0.039
Vitamin E	5	3.91	1	0.83	2.48	0.116
Mineral salts	0	0.00	1	0.83	1.07	0.303
Biotin	4	3.13	1	0.83	1.65	0.201
Alanine, L-Citrulline, Berberine, Guarana, Silymarin, Carbohydrate (energy) bars	2	1.56	5	4.17	1.53	0.218

1	2	3	4	5	6	7
Iron	7	5.47	0	0.00	6.75	0.009
Potassium	3	2.34	0	0.00	2.85	0.092
Vitamins for those planning a pregnancy	2	1.56	0	0.00	1.89	0.171
Folic Acid	2	1.56	0	0.00	1.89	0.171
Other micro/macro elements (Calcium, Selenium)	1	0.78	0	0.00	0.94	0.334
Horsetail, Royal jelly, Piperine, Curcumin	4	3.13	1	0.83	1.65	0.201

In the Fitness Group, 52.50% of the women had been training for over a year, with most of them, 87.50%, training between 1 and 2 hours a day, 3–4 times a week (72.50%) (Table 2). The main forms of training are strength training (95.83%) and cardio training on equipment such as a treadmill or bike (62.50%).

Sweets and fast food were eaten usually only once or twice a week by the women who were training (62.50%). Vegetables and fruit were consumed daily by 79.19% of women from the Fitness Group, while fish was eaten much less frequently with only 56.66% eating fish either less than once a week or never. The processed products were consumed by only 17.50% of the women who trained, and frying, as a meal preparation method, was occasionally used by 55.00% of the respondents, and not at all by 25.00% of them. Calories were counted during meals by 60.00% of women from the Fitness Group.

The Internet was the source of knowledge on healthy eating for 95.83% of the women who trained, while 42.50% of them used the advice of a dietitian.

Table 2. Time and type of training, sources of knowledge about nutrition and nutritional behaviour in the Fitness Group

Question	Answer	n (%)
1	2	3
How long have you exercised at a fitness club?	Less than 1 month	7 (5.83)
	1–3 months	20 (16.67)
	3–6 months	12 (10.00)
	6 months–1 year	18 (15.00)
	Longer than a year	63 (52.50)
How long do you workout for?	Less than one hour	10 (8.33)
	From 1 to 2 hours	105 (87.50)
	More than 2 hours	5 (4.17)
How many times a week do you go to the fitness club?	1–2	16 (13.33)
	3–4	87 (72.50)
	5–7	17 (14.17)
What type of training do you do?	Weight training	115 (95.83)
	Crossfit	10 (8.33)
	Calisthenics	7 (5.83)
	Yoga	7 (5.83)
	Cardio machines (treadmill, bicycle)	75 (62.50)
	Organised classes at the club	21 (17.50)
	Is your training supervised by a personal trainer?	31 (25.83)

1	2	3
What is your main source of information about healthy eating?	Internet	107 (89.17)
	Specialist literature	54 (45.00)
	Advice of a dietitian	51 (42.50)
	Advice of friends	26 (21.67)
	Magazines	21 (17.50)
How many times a week do you consume sweets, fast food, etc?	0	13 (10.83)
	1–2	75 (62.50)
	2–3	0 (0.00)
	3–4	20 (16.67)
	5–7	12 (10.00)
How many times a week do you eat fruit and vegetables?	Hardly ever	2 (1.67)
	A few times a week	23 (19.17)
	Every day	95 (79.17)
How often do you eat fish?	Never	25 (20.83)
	Less than once a week	43 (35.83)
	Once a week	40 (33.33)
	More than once a week	12 (10.00)
Do you eat fried foods?	Never	30 (25.00)
	Occasionally	66 (55.00)
	Often	0 (0.00)
	Very often	24 (20.00)
Do you eat processed foods?	Yes	21 (17.50)
Do you count calories?	Yes	72 (60.00)

An analysis of the correlation between age, BMI, time and type of training, sources of knowledge about diet in sport, eating behaviours along with the consumption of protein products, dietary supplements and creatine, carried out in the Fitness Group, showed the following relationships. The older the woman, the more often she took supplements ($R = 0.28$, $p < 0.01$) and creatine ($R = 0.22$, $p < 0.05$) (Appendix A). The longer she had been attending the Fitness Club, the more often she used supplements ($R = 0.36$, $p < 0.01$), protein products ($R = 0.33$, $p < 0.01$) and creatine ($R = 0.32$, $p < 0.01$). Obtaining information from magazines was associated with a more frequent use of protein products ($R = 0.20$, $p < 0.05$), while a dietary consultation increased the frequency of supplements in general ($R = 0.21$, $p < 0.05$). The consumption of vegetables was positively correlated with the general use of supplements ($R = 0.18$, $p < 0.05$) and protein products ($R = 0.26$, $p < 0.01$). Fish consumption was positively correlated with protein supplements ($R = 0.18$, $p < 0.05$). Calorie counting was associated with more frequent general supplementation ($R = 0.26$, $p < 0.01$), and creatine ($R = 0.20$, $p < 0.05$).

Logistic regression confirmed most of the dependencies shown in the correlations. A positive predictor of the use of protein products was the higher frequency of consumption of vegetables (Table 3).

Table 3. Multiple logistic regression analysis for the use of protein product predictors

	B	p	OR	95% C.I. for OR	
				lower	upper
Age (years)	0.00	0.961	1.00	0.84	1.18
BMI (kg/m^2)	–0.17	0.069	0.84	0.70	1.01
How long have you exercised at a fitness club?	0.36	0.065	1.43	0.98	2.09
How long do you workout for?	0.19	0.791	1.21	0.29	5.06
Weight training	1.70	0.280	5.49	0.25	120.28
Crossfit	–0.29	0.770	0.75	0.11	5.20
Calisthenics	0.05	0.960	1.05	0.14	8.12
Yoga	0.30	0.788	1.35	0.15	11.76
Cardio machines (treadmill, bicycle)	–0.17	0.726	0.84	0.32	2.24
Organised classes at the club	–0.03	0.965	0.97	0.26	3.59
Internet	–0.17	0.839	0.85	0.17	4.20
Magazines	1.01	0.161	2.76	0.67	11.37
Specialist literature	0.10	0.853	1.10	0.39	3.15
Advice of a dietitian	0.49	0.347	1.63	0.59	4.54
Advice of friends	–0.18	0.778	0.84	0.24	2.86
How many times a week do you consume sweets, fast food, etc?	0.32	0.094	1.37	0.95	1.99
How many times a week do you eat fruit and vegetables?	1.26	0.029	3.53	1.13	11.01
How often do you eat fish?	0.43	0.166	1.54	0.84	2.84
Do you eat processed foods?	0.74	0.311	2.11	0.50	8.89
Do you eat fried foods?	–0.53	0.073	0.59	0.33	1.05
Do you count calories?	0.29	0.574	1.34	0.48	3.74

Positive predictors of the use of general supplementation, excluding protein products, were: age, number of months of training, using the advice of a dietitian and calorie counting (Table 4).

Table 4. Multiple logistic regression analysis of general supplementation predictors

	B	p	OR	95% CI. for OR	
				lower	upper
1	2	3	4	5	6
Age (years)	0.27	0.004	1.32	1.09	1.59
BMI (kg/m^2)	–0.15	0.168	0.86	0.70	1.06
How long have you exercised at a fitness club?	0.59	0.009	1.80	1.15	2.81
How long do you workout for?	0.91	0.284	2.48	0.47	13.13
Weight training	–1.50	0.395	0.22	0.01	7.10
Crossfit	–1.30	0.266	0.27	0.03	2.70
Calisthenics	–1.38	0.221	0.25	0.03	2.28
Yoga	–0.59	0.609	0.56	0.06	5.25

1	2	3	4	5	6
Cardio machines (treadmill, bicycle)	0.14	0.800	1.15	0.39	3.41
Organised classes at the club	–1.02	0.170	0.36	0.09	1.54
Internet	–1.08	0.247	0.34	0.06	2.11
Magazines	0.26	0.713	1.30	0.32	5.22
Specialist literature	–0.19	0.743	0.83	0.27	2.52
Advice of a dietitian	1.50	0.009	4.49	1.45	13.87
Advice of friends	0.59	0.364	1.81	0.50	6.49
How many times a week do you consume sweets, fast food, etc?	0.02	0.935	1.02	0.68	1.51
How many times a week do you eat fruit and vegetables?	0.84	0.201	2.33	0.64	8.50
How often do you eat fish?	–0.22	0.477	0.80	0.44	1.47
Do you eat processed foods?	0.30	0.712	1.35	0.28	6.52
Do you eat fried foods?	–0.10	0.742	0.90	0.49	1.65
Do you count calories?	1.54	0.008	4.65	1.49	14.53

Positive predictors of the use of creatine supplements were age and calorie counting (Table 5).

Table 5. Multiple logistic regression analysis of the use of creatine predictors

	B	p	OR	95% CI.for OR	
				Lower	Upper
1	2	3	4	5	6
Age	0.54	0.002	1.71	1.21	2.42
BMI	–0.40	0.072	0.67	0.43	1.04
How long have you exercised at a fitness club?	0.87	0.062	2.39	0.96	5.94
How long do you workout for?	1.38	0.137	3.98	0.64	24.54
Weight training	13.96	0.999[#]	1,150,805.94[#]	0.00[#]	[#]
Crossfit	–1.72	0.300	0.18	0.01	4.62
Calisthenics	0.96	0.441	2.62	0.23	30.43
Yoga	–22.56	0.998[#]	0.00[#]	0.00[#]	0.00[#]
Cardio machines (treadmill, bicycle)	–0.62	0.362	0.54	0.14	2.03
Organised classes at the club	–1.83	0.130	0.16	0.01	1.72
Internet	–0.71	0.582	0.49	0.04	6.20
Magazines	0.47	0.616	1.60	0.25	10.08
Specialist literature	–0.53	0.522	0.59	0.12	2.98
Advice of a dietitian	–0.01	0.988	0.99	0.24	4.13
Advice of friends	–0.51	0.564	0.60	0.10	3.42
How many times a week do you consume sweets, fast food, etc?	0.50	0.148	1.64	0.84	3.22
How many times a week do you eat fruit and vegetables?	0.02	0.985	1.02	0.20	5.10
How often do you eat fish?	–0.84	0.081	0.43	0.17	1.11
Do you eat processed foods?	0.68	0.557	1.98	0.20	19.29

1	2	3	4	5	6
Do you eat fried foods?	0.13	0.743	1.14	0.52	2.53
Do you count calories?	2.09	0.022	8.09	1.35	48.32

For strength training, calculating the confidence intervals is impossible as the result for the number of people who do not practice strength training and who, at the same time, use creatine supplementation was zero (strength training no – creatine yes). Similarly, the result for the number of people who are both practising yoga and using creatine at the same time was also zero (yoga yes – creatine yes).

Discussion

Dietary supplements have become a common and convenient form of supplementing the diet with nutrients. The use of modern technologies in the production of food for special purposes can guarantee a combination of all the nutrients needed to support the achievement of a specific training goal in any given dietary source (bar, drink) (Gavrilova et al., 2020). Supplements for athletes are easy to consume, have hygienic packaging, are convenient to transport, for example, to the gym, so they are easily accessible before, during, and after training. Dietary supplements are a practical way to deliver a specific combination of key nutrients when they are needed. However, only a proper diet can provide the athlete with all the nutrients necessary to maintain top sporting condition. However, selecting food products containing all the necessary nutrients and preparing well-balanced meals from them requires extensive knowledge of their nutritional value and such knowledge is not available to a person uneducated in these matters (Burke, Hawley, 2018).

Supplements that are allowed to be used in sports can be divided into those that increase muscle mass, those that accelerate fat burning, those that increase the immune system of the body and regenerate joints and those that improve mental performance (Frączek, Gacek, Grzelak, 2012; Fielding, Riede, Lugo, Bellamine, 2018) The Australian Sports Commission (*Supplements* | *Australian Institute of Sport* (*ais.gov.au*)) have divided dietary supplements, intended for athletes, into 4 groups based on scientific research and evidence of their effectiveness, usefulness, and safety. It is worth mentioning only the first group of these preparations, because they include those with scientifically proven positive effects for athletes, they are: sports food (sports drinks (isotonic drinks), bars, gels, confectionery, liquid meals, whey protein and electrolyte replacement), medical supplements (iron, calcium, multivitamin/mineral, vitamin D, probiotics), performance supplements (caffeine, β-alanine, bicarbonate, beetroot juice, and carnitine) (*Supplements* | *Australian Institute of Sport* (*ais.gov.au*)).

This study showed that 40.83% of women who trained in fitness clubs used dietary supplements, compared to 35.48% of the group of physically inactive women. However, this difference was not statistically significant. Positive predictors of general supplement use were age, number of months of training, use of advice from a dietitian, and calorie counting. The age of the women who trained in fitness clubs ranged from 16 to 31 years. The more frequent use of supplements by older female athletes could result, for example, from the very process of education and the general acquisition of knowledge on various topics that occur during daily functioning in society. Often, this is how women find out a lot about nutrients and gain the basis for their independent research on nutrition in sports. Perhaps slightly older respondents have also begun to feel the onset of changes related to a decrease in overall efficiency of the body, inevitably connected with age. As their general knowledge about nutrition was higher, they were more likely to use supplements.

It seems that women who train longer strive to maximise the effects of their training and, hence, take steps to support their dietary needs. Additionally, in order to count calories, it is necessary to have at least a basic knowledge about the caloric value of the food eaten, which shows that the women surveyed have a greater interest in sports nutrition. A positive phenomenon in the women training in fitness clubs is more frequent use of supplements after consulting a dietitian. Certainly, consulting a dietitian does not guarantee sound supplementation. However, it is more likely to be consistent with the needs of an exercising woman's body.

In the Fitness Group, 60.00% of the women supplemented their diet with protein supplements, but this was not observed in the Control Group. A positive predictor of the use of protein supplements was the higher frequency of vegetable consumption. This could be due to the fact that the women were aware that only some vegetables are rich in protein and they therefore concluded that when consuming a lot of vegetables, they should additionally supplement their protein with protein products. The literature on the subject states that physically active people should supplement their daily diet with protein in the amount of approximately 1.4 to 2.0 g of protein per kilogram of body weight per day to maintain nitrogen balance (Maughan et al., 2018; Kerksick et al., 2018). The lack of a sufficient amount of protein in an athlete's diet may contribute to slower adaptation of the body to physical exertion and reduced post-exercise regeneration. Protein products, designed for athletes, provide the opportunity to consume high-quality protein when needed. If insufficient protein is obtained from the diet, the athlete will maintain a negative nitrogen balance, which can increase protein catabolism in the body and, over time, lead to muscle wasting and training intolerance. In addition, increasing protein intake during weight loss, which is often a motivation for young women to exercise in fitness clubs, helps to maintain muscle mass. For those involved in a general fitness program, protein needs can generally be met with a consumption of 0.8–1.0g of protein/kg/day. The best sources of high-quality protein found in dietary supplements are: whey, colostrum, casein, milk proteins and egg white (Nemet, Eliakim, 2007; Poulios et al., 2019; Whitehouse, Lawlis, 2017; Rusu, Popa, 2016).

The group of dietary supplements used by the women exercising in fitness clubs also included: creatine, L-carnitine, fat reducers (thermogenics), ashwagandha, collagen and β-alanine. Creatine, which is currently the most popular supplement used by athletes in the world, turned out to be the most popular dietary supplement among the sportswomen (Andres et al., 2017; Butts, Jacobs, Silvis, 2018; Mielgo-Ayuso et al., 2019; Awgul, Głąbowski, Kopeć, Sroczyński, 2017; Kreider et al., 2017). The results of this research confirmed that creatine was consumed the most frequently of all the dietary supplements used by the women exercising in a fitness club with 17.50% of them using this supplement. In the Control Group, this supplement was not used at all. Age and calorie counting were positive predictors of creatine use in the Fitness Group. The reasons for the positive effect of age and calorie counting on creatine use are certainly related to the reasons for the use of general supplements. A creatine molecule is the basic energy carrier in muscle cells and therefore contributes to increasing the intensity and efficiency of muscle activity, boosting their strength, promoting faster muscle mass growth and their efficiency and regeneration, and hence improving physical efficiency. This increase in muscle mass is the result of an improvement in the muscle's ability to perform high-intensity exercise, thus allowing the athlete to exercise harder, thereby promoting greater training adaptations and muscle hypertrophy. Supplementing the diet with creatine monohydrate and/or creatine seems to be a safe and effective method of increasing muscle mass and preventing sports injuries (Andres et al., 2017; Butts et al., 2018; Mielgo-Ayuso et al., 2019; Awgul at al., 2017; Kreider et al., 2017). The position of the International Society of Sport Nutrition (ISSN) (Kerksick et al., 2018) on the use of creatine is positive and confirms that creatine monohydrate is currently the most widely researched and clinically effective form of creatine used in dietary supplements for athletes and is therefore the most effective ergogenic aid. It facilitates an increase in the exercise capacity of muscles and lean body mass during exercise. Supplementation in young athletes is acceptable and can constitute a nutritional alternative to potentially dangerous anabolic drugs. The fastest method to increase creatine stores appears to be to consume around 0.3g/kg/day of creatine monohydrate for at least 3 days, followed by 3–5 g/day (Kerksick et al., 2018).

Vitamin complexes and vitamin D, i.e., a group of compounds supplying the body in an exogenous way and fulfilling an important role in every aspect of the body's functioning (Maughan et al., 2018; Kerksick et al., 2018; Williams, 2004; Bojanić, Radović, Bojanić, Lazović, 2011) came after creatine. They were the most frequently used dietary supplements among the female athletes surveyed. Both the vitamin complexes, which, unfortunately, were not named by the women surveyed and therefore their exact composition cannot be verified, and vitamin D were used by 10.00% of the women who trained. In comparison, in the physically inactive Control Group, significantly fewer women (3.13%) used vitamin complexes, and only slightly more (14.84%) used vitamin D. Vitamin D regulates the balance of calcium and phosphorus and, together with these elements, is responsible for bone remodelling. Vitamin D deficiency leads to calcium malabsorption and consequently to deterioration of bone mineralization and bone fractures. It also has an effect on the correct performance of the musculoskeletal and nervous systems and mobilises the immune system (Maughan et al., 2018; Kerksick et al., 2018; Williams, 2004; Bojanić et al., 2011).

The exogenous amino acids BCAAs which include: valine, leucine and isoleucine, took next place in terms of the popularity of use by the women exercising in fitness clubs but not used at all in the Control Group. BCAAs are key amino acids that stimulate protein synthesis (Maughan et al., 2018; Kerksick et al., 2018; Waldron et al., 2017; Van Dusseldorp et al., 2018). Generally, supplementation with Essential Amino Acids (EAAs), which also includes BCAAs, should be at levels of 3–6 g of amino acids after exercise. This can increase protein synthesis, muscle mass, and training adaptations, and also delay the effects of fatigue. Consumption of BCAA alone (6–10 g per hour) before, during and after exercise is recommended as safe and effective for athletes. The recommendations for this type of preparation are related to the fact that these amino acids act as an energy substrate, are easily digestible, help build muscle mass, contribute to the inhibition of muscle catabolism, show strong anabolic properties, delay the occurrence of fatigue after long and intense training, and have a positive effect on the immune system (Maughan et al., 2018; Kerksick et al., 2018; Waldron et al., 2017; Van Dusseldorp et al., 2018).

Women who practise sports usually avoid fat in their daily diet. In this study, there was some supplementation with fish oil and omega acids – used by 7.50% of the respondents. When discussing fat consumption in the daily diet, it should be mentioned that athletes are recommended to consume a moderate amount of fat, that is, approximately 30% of their daily caloric intake, and up to 50% with heavy load training.

For athletes trying to reduce body fat, an intake of 0.5–1.0 g/kg/day of fat is recommended. Fats help replenish intramuscular triacylglycerol and maintain circulating testosterone levels (Maughan et al., 2018; Kerksick et al., 2018). However, what is important is that the athletes must be knowledgeable about the existence of various types of fats with different saturation levels, so they should be able to choose the best and most valuable of them for themselves (Venkatraman, Leddy, Pendergast, 2000). Omega 3, 6 and 9 fatty acids, as well as docosahexaenoic acid (DHA) and eicosapantaenoic acid (EPA) are extremely important for the health of the entire body, including the cardiovascular system. For general health, dosing guidelines range from 3,000 mg to 5,000 mg daily (Thielecke, Blannin, 2020). When comparing the fish oil/omega acids supplementation in the Fitness Group and the Control

Group, it can be seen that their use is significantly higher among the women who exercise (7.50% vs 1.56%), so it may be considered that some physically active women know about the benefits of such supplementation.

A small percentage of the sportswomen took vitamin C (2.50%), compared to the Control Group, where the consumption of this vitamin was slightly higher (6.25%). Vitamin C increases the body's immunity and has a beneficial effect on the states of fatigue and overtraining. It also acts as a biocatalyst in indirect carbohydrates metabolism and exerts a specific effect on stress responses by participating in adrenal hormone synthesis (Williams, 2004; Bojanić et al., 2011). Antioxidants, including vitamins C and E (Higgins, Izadi, Kaviani, 2020), have been identified as possible substances to improve athletic performance. In this study, a few women used these vitamins, 2.50% and 0.83%, respectively, of the women surveyed. Increased oxidative stress during training causes the production of free radicals, leading to muscle damage, fatigue, and a decrease in body performance. However, it has been shown that the above-mentioned vitamins also tend to block anabolic signalling pathways and thus impair adaptation to resistance training, so special care should be taken when using them. It is recommended that athletes eat a diet rich in fruit and vegetables that provide vitamins, minerals and other bioactive compounds to meet the recommended intake of vitamins C and E (Higgins et al., 2020).

The next supplements used by the women training in fitness clubs are the B vitamins. They were taken by 3.33% of women from the Fitness Group and 6.25% of women from the Control Group. The B vitamins are necessary for the production of energy and the synthesis and production of hormones. A lack of them interferes with the proper functioning of the body, contributing to the formation of diet-related diseases (Maughan et al., 2018; Kerksick et al., 2018; Williams, 2004; Bojanić et al., 2011). Furthermore, the B vitamins contribute to the accumulation of glycogen in the liver, take part in reduction and oxidation reactions as components of respiratory enzymes, participate in the indirect metabolism of carbohydrates, fats and proteins, increase the use of oxygen by tissues and accelerate the synthesis of glycogen in the liver and muscles. Several women from the Fitness Group reported taking vitamins A (0.83%), E (0.83%) and K (2.50%). In the Control Group, the use of vitamin A was considerably higher (5.47%), vitamin E slightly higher (3.91%) and vitamin K slightly lower (0.78%). These are fat-soluble vitamins that help prevent infections, regenerate soft tissues, vitamin A, protect against free radicals, vitamin E, and have an impact on proper muscle function, vitamin K. In addition, regular use of vitamins A and E, which belong to the group of antioxidant vitamins that protect the body against oxidative stress induced by intense physical effort, contributes to increasing the antioxidant potential of cells and prevent tissue damage after exercise (Maughan et al., 2018; Kerksick et al., 2018; Williams, 2004; Bojanić et al., 2011). Presumably, the relatively high frequency of vitamin A and E use in the physically inactive group is associated with the positive effect of these vitamins on hair, skin and nails (Bojarowicz, Płowiec, 2010). It should also be noted that two respondents from the Fitness Group (1.7%) used probiotic bacteria, which help to maintain the proper composition of the intestinal flora, which brings many health benefits, including a positive effect on the immune functions of the body (Jäger et al., 2019; Zeppa et al., 2020). In the Control Group, none of the women made use of the properties of this "good" bacteria. Probiotics, often referred to as "friendly" or "good" bacteria, are living microorganisms that, when administered in appropriate amounts, contribute to the health benefits of their host. It is estimated that 70% of a person's immune system is in the digestive system, indicating the importance of a balanced intestinal microflora (Jäger et al., 2019; Zeppa et al., 2020).

During training, the athlete is exposed to the loss of significant amounts of mineral salts, mainly sodium, potassium, magnesium, calcium, and iron, which are inorganic elements necessary for the formation of many metabolic processes. In response to long training sessions, athletes are exposed to a significant shortage of minerals lost by the body in sweat. When the mineral status of the body is insufficient, exercise capacity can be significantly impaired. Supplementing the athlete's diet with minerals is important to restore the body's efficiency to the state before the training session, or to increase the exercise capacity of, for example, muscles. Minerals are important components of enzymes and hormones. They serve as structural elements for tissues and are regulators of the nervous system (Maughan et al., 2018; Kerksick et al., 2018). These elements are involved in the regulation of water-electrolyte and acid-base balance and neuromuscular excitability. They also impact the proper functioning of the heart and skeletal muscles and stimulate hematopoietic processes. Furthermore, as an activator of many enzymes, magnesium is involved in the metabolism of carbohydrates and fats (Maughan et al., 2018; Kerksick et al., 2018; Valenta, Dorofeeva, 2018). Iron, thanks to which oxygen is transported to all cells, ensures the proper functioning of the body under physical exertion. Several of the proposed nutritional ergogenic aids including: Calcium (1,000 mg/day (ages 19–50), stimulate fat metabolism, are beneficial in combating premature osteoporosis, help maintain bone mass and nerve transmission, but provide no ergogenic effect on exercise performance (Maughan et al., 2018; Kerksick et al., 2018; Valenta, Dorofeeva, 2018). It was used by 0.78% of the Control Group and 0.00% of the Fitness Group. Magnesium (males 420mg/day, females 320 mg/day) affects the activation of enzymes involved in protein synthesis and may improve energy metabolism (ATP availability). Supplementation with magnesium (500 mg/day) does not affect exercise performance in athletes unless there is a deficiency (Maughan et al., 2018; Kerksick et al., 2018; Valenta, Dorofeeva, 2018). It was used by 5.47% of women in the Control Group and 2.50% in the Fitness Group. Iron (males 8mg/day, females 18 mg/day – age 19–50) is a component of haemoglobin and iron supplementation is especially important in increasing aerobic capacity, although, most research shows that iron supplements do not appear to improve aerobic performance unless the athlete is iron-depleted and/or has anaemia (Maughan et al., 2018; Kerksick et al., 2018; Valenta, Dorofeeva, 2018). It was used by 5.47% of the respondents from the Control Group and 0.00% of the Fitness Group and it was a statistically significant difference. Potassium (2,000 mg/day) plays a role in nerve conduction and helps regulate acid-base balance and regulates body fluid balance. Potassium loss during intense exercise in the heat has been anecdotally associated with muscle cramping, but no ergogenic effects have been reported. It was used by 2.34% of people from the Control Group and 0.00% of the Fitness Group. Zinc (males 11mg/day, females 8mg/day) possesses properties which reduce upper respiratory tract infections. Studies have shown that supplementation (25 mg/day) minimised exercise-induced changes in immune function (Maughan et al., 2018; Kerksick et al., 2018; Valenta, Dorofeeva, 2018). It was used by 0.78% of women in the Control Group and 1.67% of the Fitness Group.

A deficiency of key minerals can lead to painful, sudden, and involuntary contractions of the skeletal muscles, as well as exhaustion and increased acidification of the body caused by a high-protein diet and hard training sessions (Maughan et al., 2018; Kerksick et al., 2018; Valenta, Dorofeeva, 2018). This research has shown that women who trained in fitness clubs do not supplement with single mineral salts. It was found that 10% of the women used vitamin complexes, which possibly contained these salts. However, it should be remembered that the consumption of vegetables and fruit by sportswomen was at a satisfactory level, therefore, it can be assumed that the diet of the women training in the fitness clubs is not deficient in these elements.

L-carnitine was another example of support for the body system that sportswomen used. It was used by 2.50% of women from the Fitness Group, but it was not used at all in the Control Group. The job of L-carnitine is to transport long-chain fatty acids. These acids are the main source of energy for the muscles of a person who performs moderate-intensity exercise. L-carnitine increases the rate of fatty acid oxidation in working muscles and delays the use of glycogen and the development of fatigue (Fielding, Riede, Lugo, Bellamine, 2018; Durazzo et al., 2020; Burrus, Moscicki, Matthews, Paolone, 2018). L-carnitine is one of the most common nutrients in weight loss supplements. Preliminary studies have reported that L-carnitine supplementation has a minimal effect on reducing biomarkers of exercise-induced oxidative stress. Although these results are not promising, there is some recent evidence that supplementation with L-carnitine tartrate during increased periods of training may help athletes endure training to a greater degree. In connection with the presented research, it can be concluded that there are probably other advantages of L-carnitine supplementation than just the promotion fat metabolism (Fielding et al., 2018; Durazzo et al., 2020; Burrus et al., 2018).

Some women from the Fitness Group (2.50%), unlike the Control Group, also used thermogenics, i.e., substances that increase the metabolic rate by increasing body temperature, and thus stimulating fat metabolism and enabling a reduction in the level of adipose tissue through increased fat burning (Maughan et al., 2018; Kerksick et al., 2018).

Caffeine supplements used by 1.67% of women training and 0.00% of the Control Group are a “stimulant” of natural origin. It stimulates the body relatively quickly to greater physical and mental performance. The energising effect of caffeine is manifested by stimulating the central nervous system, helping to overcome fatigue and training stagnation. Moreover, it reduces glycogen breakdown and, at the same time, increases fat metabolism (Bruce et al., 2000). Scientific research has shown that although caffeine can have a positive effect on energy expenditure and weight loss by reducing body fat, in people who regularly consume drinks containing caffeine the benefits are limited. Studies have also shown (Bruce et al., 2000; Okuroglu et al., 2019; Burke, 2008), that caffeine consumption (eg 3–9 mg/kg body weight consumed 30–90 minutes before exercise) can reduce carbohydrate use during exercise and thus improve physical endurance. Caffeine doses greater than 9 mg/kg body weight in a competitor’s urine exceed the doping threshold for many sports organisations. It has also been shown that caffeine doses <9 mg / kg do not increase the effect on body performance (Bruce et al., 2000), but carry a greater risk of negative side effects, such as increased heart rate, nausea, restlessness, and insomnia. In addition, caffeine consumption before exercise has been found to dehydrate the body, although these reports contradict the scientific literature (Burke, 2008).

β-alanine was used very rarely by women in this study. β-alanine has ergogenic properties, demonstrated in scientific research based on its relationship with carnosine, which is an organic compound composed of the amino acids β-alanine and histidine, which naturally occur in large amounts in skeletal muscles (Carvalho et al., 2018). Carnosine, an endogenously water-soluble dipeptide with antioxidant properties, is the main non-protein nitrogen-containing compound in vertebrate skeletal muscles. It acts as a water-soluble equivalent of lipophilic antioxidants (e.g., α-tocopherol), inhibits lipid peroxidation, thus preventing damage to protein-lipid membranes, and plays a specific and very important role in tissues that use free radicals in the regulation of biological processes and plays a role in protection against oxidative stress. Carnosine acts as a mobile pH buffer for tissue which, due to the preferred glycolytic path of energy generation, is particularly vulnerable to acid-base imbalance (mainly striated muscles). In addition, it “buffers” reactive oxygen species in tissue, but does not completely inhibit its regulatory and signalling functions. Studies have shown that taking β-alanine orally over a period of 28 days was effective in increasing carnosine levels, and thus improving tolerance to maximal intensity exercise. Supplementation with β-alanine reduces muscle fatigue rate, shortens regeneration time, and thus increases work efficiency and muscle strength (Carvalho et al., 2018; Saunders et al., 2017; Trexler et al., 2015). The dosing guidelines for β-alanine typically includes the consumption of 3.2 to 6.4 g / day, taken in a divided dose regimen of 0.8 to 1.6 g, every 3 to 4 hours over a period of 4 to 12 weeks (Saunders et al., 2017).

In the last few years, many studies (Maughan et al., 2018; Kerksick et al., 2018; Jeukendrup, 2014; Williams, Rollo, 2015) have also shown that carbohydrates are one of the best ergogenic aids for athletes. Consumption of carbohydrates and protein immediately after exercise may increase carbohydrate storage and protein synthesis in the body and lead to greater training adaptations. Athletes and physically active people should maintain a high-carbohydrate diet (55–65% of calories or 5–8 g/kg/day) to maintain muscle and liver carbohydrate reserves (Maughan et al., 2018; Kerksick et al., 2018; Jeukendrup, 2014; Williams, Rollo, 2015). Ideally, the majority of dietary carbohydrates should come from complex carbohydrates with a low or moderate glycemic index (e.g., whole grains, vegetables, and fruit), and, if such products are not included in the diet, the athlete should take them as dietary supplements to meet the body's needs. Research shows that the body can oxidise 1.0–1.1 g of carbohydrate per minute, or about 60 g per hour (Jeukendrup, 2014; Williams, Rollo, 2015). The American College of Sports Medicine (ACSM) recommends an intake of 0.7 g/kg/hr when exercising in a 6–8% solution (i.e., 6–8 g per 100 ml of fluid) (*ACSM | The American College of Sports Medicine)*. Only one woman from the Fitness Group declared that she used carbohydrate bars.

Isotonic drinks and water are undoubtedly the most important ergogenic aids for athletes (Urdampilleta, Gómez-Zorita, 2014; Lee, Nio, WeeHon; Law, Lim, 2011; Ramos-Jiménez et al., 2014). Training performance is considered to deteriorate when body weight is reduced by 2% or more as a result of a loss of water through sweat, while a weight loss of 4% during training can lead to heat stroke and even death of the athlete (Urdampilleta, Gómez-Zorita, 2014). It is important that athletes maintain the necessary hydration for the body, which, in practice, means drinking an average of 200g of water or an isotonic drink every 5 to 15 minutes during exercise. In order to maintain fluid balance and prevent dehydration, athletes must drink 0.5 to 2 l/hr of fluid depending on the length of the training (Urdampilleta, Gómez-Zorita, 2014; Lee et al., 2011; Ramos-Jiménez et al., 2014). Importantly, fluid intake cannot depend on the perceived thirst, because only when the athlete loses a significant amount of water from the body is there a feeling of thirst. It is believed that during a training session of more than an hour, athletes should consume glucose and electrolyte drinks to maintain blood glucose levels, prevent dehydration, and reduce the immunosuppressive effects of intense exercise (Urdampilleta, Gómez-Zorita, 2014; Lee et al., 2011; Ramos-Jiménez et al., 2014). None of the women surveyed declared the use of isotonic drinks. Unfortunately, the survey did not directly ask about isotonic drinks, and women only associated supplementation with taking solid supplements. This aspect should be considered a limitation of the study.

Certainly, the selection of dietary supplements should be a well-thought-out decision made after consultation with a qualified dietitian or sports doctor. Sometimes a person, especially a recreational sportsperson, does not need any additional supplements because it is not necessary for the intensity of training and any nutritional deficiencies can be corrected from daily food sources. It is not recommended to buy supplements from unknown sources, especially with labels that offer quick effects, including those with slogans such as: stimulating, energising, enhancing, and a rapid effect. Consumers should always be informed and cautious when purchasing and consuming supplement products (Volf et al. 2020; Meng, Sun, Wu, 2015; Wójcicki, 2020).

Limitations of the study. Supplementation in sport, both competitive and amateur, is a complex, multidisciplinary scientific issue. This study only shows a general picture of supplementation taken by women training in fitness clubs on an amateur basis in comparison with women from the same population, who are physically inactive. For this reason, a number of questions remain unanswered and many points need clarification. The authors of the study know neither exactly what the training load of the amateur sportswomen was or how long it lasted, nor in what doses and in what form the supplements were taken and to what extent they corresponded to the real needs of the women's bodies. Additionally, some respondents entered "vitamin complex" in the questionnaire, which made it impossible to interpret the data. The women did not keep a dietary diary so the quantity of nutrients supplied to the body through the diet was not known. Also, specific micro- and macronutrients in their organisms were not determined. The authors did not know the general health condition of the fitness or control group and whether supplementation had been recommended by a doctor. All these limitations show what an extensive issue the subject of nutrition and supplementation in sport is and how much information is needed to ensure proper nutrition of the body during increased physical activity. However, the authors of the publication have forged a path for other researchers by revealing the issues that should be taken into account when researching the topic of supplement intake in humans. The statements of the women training in fitness clubs clearly indicate that they take supplements and nutrients, so, further research is necessary to first organise what is known and then translate it into guidelines for amateur sportswomen. Moreover, it needs to be presented in such a way that is understandable to people without any specialised education in this area.

Conclusions

In the Fitness Group, 60.00% of the women used protein products, 40.83% other dietary supplements. The most popular supplements among women exercising were creatine, vitamin complexes, vitamin D, BCAA, and fish oil/omega acids. Women in the Fitness Group, compared to women who lead a sedentary lifestyle, used more creatine, BCAA, vitamin complexes, fish oil/omega acids, and less often vitamin A and iron.

In the fitness group, protein supplements were consumed more frequently by those women who also ate vegetables more frequently. Overall consumption of supplements in the fitness group was more frequent in women who were older, exercised longer, saw a dietitian and counted calories. Creatine, on the other hand, was used more often by older women and those counting calories.

Compared to the Control Group, the supplementation of female athletes was aimed at enhancing the effects of exercise, including reducing body fat and/or increasing muscle mass. In the Control Group, the women also used dietary supplements and vitamins, but their choice was more focused on a broadly understood general strengthening of the body and improvement in the condition of the skin and hair.

As can be concluded from the above premises, a significant percentage of women, who train on an amateur basis in fitness clubs, use dietary supplements and nutrients. Is it good for their health? Are the supplements they take selected in accordance with the needs of their body? In order to answer the above questions, it makes sense to conduct further, more detailed research on supplementation used with various training loads, and then to develop some guidelines for amateur sportswomen.

Appendix A. Correlations between predictors related to supplements, protein products, creatine and training, sources of knowledge about healthy eating and eating habits. For estimated variables: Spearman's rho, for dichotomous variables: phi coefficient; *: p <.05; **: p <.01.

	Supplements	Protein products	Creatine
1	2	3	4
Age [years]	0.28**	0.07	0.22*
BMI [kg/m^2]	–0.12	–0.13	–0.09
How long have you exercised at a fitness club?	0.36**	0.33**	0.32**
How long do you workout for?	0.15	0.14	0.12
Weight training	0.09	0.17	0.10
Crossfit	–0.01	0.00	–0.06
Calisthenics	–0.06	0.06	0.07
Yoga	0.01	0.06	–0.11
Cardio machines (treadmill. bicycle)	0.01	0.04	–0.10
Organised classes at the club	–0.07	0.02	–0.10
Internet	–0.09	–0.01	–0.05
Magazines	0.06	0.20*	0.02
Specialist literature	0.03	0.12	–0.06
Advice of a dietitian	0.21*	0.15	0.05
Advice of friends	0.10	–0.02	0.02
How many times a week do you consume sweets. fast food. etc?	0.02	0.15	0.09
How many times a week do you eat fruit and vegetables?	0.18*	0.26**	0.02
How often do you eat fish?	0.04	0.18*	–0.05
Do you eat processed foods?	–0.03	–0.03	0.08
Do you eat fried foods?	–0.04	–0.04	0.03
Do you count calories?	0.26**	0.10	0.20*

References

ACSM | The American College of Sports Medicine (www.acsm.org).

Andres, S., Ziegenhagen, R., Trefflich, I., Pevny, S., Schultruich, K., Braun, H., Schanzer, W., Hirch-Ernst, K.I., Schafer, B., Lampen, A. (2017). Creatine and creatine forms intended for sports nutrition. *Molecular Nutrition & Food Research*, 61 (6), 1600772. DOI: 10.1002/mnfr.201600772.

Andrews, A., Wojcik, J.R., Boyd, J.M., Bowers, Ch.J. (2016). Sports nutrition knowledge among Mid-Major Division I university student-athletes. *Journal of Nutrition and Metabolism*, 3172460. DOI: 10.1155/2016/3172460.

Awgul, K., Głąbowski, D., Kopeć, M., Sroczyński, T. (2017). The potential benefits and side-effects resulting from creatine supplementation. *Bromatologia i Chemia Toksykologiczna*, *2*, 122–127.

Baume, N., Hellemans, I., Saugy, M. (2007). Guide to over-the-counter sports supplements for athletes. *International Journal of Sports Medicine*, *8* (1), 2–10.

Bojanić, V., Radović, J., Bojanić, Z., Lazović, M. (2011). Hydrosoluble vitamins and sport. *Acta Medica Mediterranea*, *50* (2), 68–75. DOI: 10.5633/amm.2011.0213.

Bojarowicz, H., Płowiec, A. (2010). Influence of vitamin A on skin condition. *Problemy Higieny i Epidemiologii,* 91, 352–356.

Brożyna, K., Tkaczyk, J., Rutkowska, A. (2019). Dietary supplements in sport – side effects. *Journal of Education, Health and Sport*, *9* (8), 779–782. DOI: 10.5281/zenodo.3407953.

Bruce, C.R., Anderson, M.E., Fraser, S.F., Stepto, N.K., Klein, R., Hopkins, W.G., Hawley, J.A. (2000). Enhancement of 2000-m rowing performance after caffeine ingestion. *Medicine & Science in Sports & Exercise*, *32* (11), 1958–1963. DOI: 10.1097/00005768-200011000-00021.

Burke, L.M. (2008). Caffeine and sports performance. *Applied Physiology, Nutrition and Metabolism*, *33* (6), 1319–1334. DOI: 10.1139/H08-130.

Burke, L.M., Hawley, J.A. (2018). Swifter, higher, stronger: What's on the menu? *Science*, *362* (6416), 781–787. DOI: 10.1126/science.aau2093.

Burrus, B.M., Moscicki, B.M., Matthews, T.D., Paolone, V.J. (2018). The effect of acute L-carnitine and carbohydrate intake on cycling performance. *International Journal of Exercise Science*, *11* (2), 404–416.

Butts, J., Jacobs, B., Silvis, M. (2018). Creatine use in sports. *Sports Health*, *10* (1), 31–34. DOI: 10.1177/1941738117737248.

Carvalho, V.H., Oliveira, A.H.S., de Oliveira, L.F., da Silva, R.P., Di Mascio, P., Gualano, B., Artioli, G.G., Medeiros, M,H.G. (2018). Exercise and β-alanine supplementation on carnosine-acrolein adduct in skeletal muscle. *Redox Biology*, *18*, 222–228. DOI: 10.1016/j.redox.2018.07.009.

Durazzo, A., Lucarini, M., Nazhand, A., Souto, S.B., Silva, A,M., Severino, P., Souto, E.B., Santini, A. (2020). The nutraceutical value of carnitine and its use in dietary supplements. *Nutrients*, *25* (9), 2127. DOI: 10.3390/molecules25092127.

Fielding, R., Riede, L., Lugo, J.P., Bellamine, A. (2018). L-Carnitine supplementation in recovery after exercise. *Nutrients*, *10* (3), 349. DOI: 10.3390/nu10030349.

Frączek, B., Gacek, M., Grzelak, A. (2012). Nutritional support of physical abilities in a professional athletes' group. *Problemy Higieny i Epidemiologii*, *93* (4), 817–823.

Gavrilova, N., Chernopolskaya, N., Rebezov, M., Schetinina, E., Dogareva, N., Likhodeevskaya, O., Knysh, I., Sankova, Z. (2020). Specialized sports nutrition foods: review. *International Journal of Pharmaceutical Research*, *12*, 998–1003. DOI: 10.31838/ijpr/2020.12.02.0152.

Harty, P.S., Zabriskie, H.A., Erickson, J.L., Molling, P.E., Kerksick, Ch.M., Jagim, A.R. (2018). Multi-ingredient pre-workout supplements, safety implications, and performance outcomes: a brief review. *Journal of International Society of Sports Nutrition*, *15* (1), 41. DOI: 10.1186/s12970-018-0247-6.

Higgins, M.R., Izadi, A., Kaviani, M. (2020). Antioxidants and exercise performance: with a focus on vitamin E and C supplementation. *International Journal of Environmental Research and Public Health*, *17* (22), 8452. DOI: 10.3390/ijerph17228452.

Housman, J.M., Dorman, S.M. (2008). Diatery and sports supplements: the need for a systematic tracking system. *American Journal of Health Studies*, 23, 35–40.

Jäger, R., Mohr, A.E., Carpenter, K.C., Kerksick, Ch.M., Purpura, M., Moussa, A., Townsend, J.R., Lamprecht, M., West, N.P., Black, K., Gleeson, M., Pyne, D.B., Wells, S.D., Arent, S.M., Smith-Ryan, A.B., Kreider, R.B., Campbell, B.I., Bannock, L., Scheiman, J., Wissent, C.J., Pane, M., Kalman, D.S., Pugh, J.N., A Ter Haar, J., Antonion, J. (2019). International Society of Sports Nutrition Position Stand: Probiotics. *Journal of the International Society of Sports Nutrition*, *16* (1), 62. DOI: 10.1186/s12970-019-0329-0.

Jeukendrup, A.A. (2014). Step towards personalized sports nutrition: carbohydrate intake during exercise. *Sports Medicine*, 44 (Suppl. 1), 25–33. DOI: 10.1007/s40279-014-0148-z.

Jîtcă, G., Tero-Vescan, A., Miklos, A., Vari, C-E., Ősz, B.E. (2018). Differences in dietary supplements used by performance athletes and recreationally active individuals. Campiono Italiano Velocita. *Sport*, *19* (3), 153–157. DOI: 10.26659/pm3.2018.19.3.153.

Kerksick, Ch.M., Wilborn, C.D., Roberts, M.D., Smith-Ryan, A., Kleiner, S.M., Jäger, R., Collins, R., Cooke, M., Davis, J.N., Galvan, E., Greenwood, M., Lowely, L.M., Wildman, R., Antonio, J., Kreider, R.B. (2018). ISSN exercise & sports nutrition review update: research & recommendations. *Journal of International Society of Sports Nutrition*, *15* (1), 38. DOI: 10.1186/s12970-018-0242-y.

Kotnik, K.Z., Jurak, G., Starc, G., Puc, M., Golja, P. (2018). Use of dietary supplements in differently physically active adolescents. *Journal of Food and Nutrition Research*, *57* (8), 231–241.

Kreider, R.B., Kalman, D.S., Antonio, J., Ziegenfuss, T.N., Wildman, R., Collins, R., Candow, D.G., Kleiner, S.M., Almada, A.L., Lopez, H.L. (2017). International Society of Sports Nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine. *Journal of International Society and Sports Nutrition*, *14*, 18. DOI: 10.1186/s12970-017-0173-z.

Krejpcio, Z., Skwarek, K., Hyżyk, A.K., Dyba, S. (2011). Evaluation of prevalence of dietary supplements intake in a selected group of sports people. *Problemy Higieny i Epidemiologii*, *92* (4), 935–938.

Lee, J.K.W., Nio, A.Q.X., WeeHon; A., Law, L.Y.L., Lim, Ch.L. (2011). Effects of ingesting a sports drink during exercise and recovery on subsequent endurance capacity. *European Journal of Sports Science, 11* (2), 77–86. DOI: 10.1080/17461391.2010.487115.

Martinovic, D., Tokic, D., Vilovic, M., Rusic, D., Bukic, J., Bozic, J. (2021). Sport dietary supplements and physical activity in biomedical students. *International Journal of Environmental Research and Public Health*, *18* (4), 2046. DOI: 10.3390/ijerph18042046.

Maughan, R.J., Burke, L.M., Dvorak, J., Larson-Meyer, D.E., Peeling, P., Phillips, S.M., Rawson, E.S., Walsh, N.P., Garthe, I., Geyer, H., et al. (2018). IOC consensus statement: dietary supplements and the high-performance athlete. *British Journal of Sports Medicine*, *52* (7), 439-455. DOI: 10.1136/bjsports-2018-099027.

Maughan, R.J., Shirreffs, S.M. (2018). Making decisions about supplement use. International Journal of Sport Nutrition and Exercise Metabolism, *28* (2), 212–219. DOI: 10.1123/ijsnem.2018-0009.

Meng, X., Sun, J., Wu, M. (2015). Market structure and case analysis of sport nutrient food industry. *Journal of Food Science and Technology*, *7*, 82–87.

Mielgo-Ayuso, J., Calleja-Gonzalez, J., Marqués-Jiménez, D., Caballero-García, A., Córdova, A., Fernández-Lázaro, D. (2019). Effects of creatine supplementation on athletic performance in soccer players: a systematic review and meta-analysis. *Nutrients*, *11* (4), 757. DOI: 10.3390/nu11040757.

Mujika, I., Burke, L.M. (2010). Nutrition in Team Sports. *Annals of Nutrition and Metabolism*, *57* (Suppl 2), 26–35. DOI: 10.1159/000322700.

Nemet, D., Eliakim, A. (2007). Protein and amino acid supplementation in sport. *International Journal of Sports Medicine Journal*, *8* (1), 11–23. DOI: 10520/EJC48606.

Okuroglu, E., Tekin, T., Kuloglu, M., Mercan, S., Bavunoglu, I., Acikkol, M., Turkmen, Z. (2019). Investigation of caffeine concentrations in sport supplements and inconsistencies in product labelling. *Journal of Chemical Metrology*, *13* (1), 21–28. DOI: 10.25135/jcm.25.19.04.1252.

Peeling, P., Castell, L.M., Derave, W., de Hon, O., Burke, L.L. (2019). Sports foods and dietary supplements for optimal function and performance enhancement in track-and-field athletes. *International Journal of Sport Nutrition and Exercise Metabolism*, *29* (2), 198–209. DOI: 10.1123/ijsnem.2018-0271.

Poulios, A., Georgakouli, K., Draganidis, D., Deli, Ch.K., Tsimeas, P.D., Chatzinikolaou, A., Papanikolaou, K., Batrakoulis, A., Mohr, M., Jamurtas, A.Z., Fatouros, IG. (2019). Protein-based supplementation to enhance recovery in team sports: what is the evidence? Journal of Sports Science and Medicine, *18* (3), 523–536.

Ramos-Jiménez, A., Hernández-Torres, R.P., Wall-Medrano, A., Torres-Durán, P.V., Juárez-Oropeza, M.A., Viloria, M., Villalobos-Molina, R. (2014). Gender- and hydration-associated differences in the physiological response to spinning. *Nutriction Hospitalaria*, *29* (3), 644–651. DOI: 10.3305/nh.2014.29.3.7017.

Rawson, E.S., Miles, M.P., Larson-Meyer, D.E. (2018). Dietary supplements for health, adaptation, and recovery in atheltes. *International Journal of Sport Nutrition and Exercise Metabolism*, *28* (2), 188–199. DOI: 10.1123/ijsnem.2017-0340.

Rusu, M.E., Popa, D.S. (2016). Protein food and amino acid supplements in athletes' diet. Campiono Italiano Velocita. *Sport*, *17* (2), 146–152.

Santesteban Moriones, V., Ibáñez Santos, J. (2017). Ergogenic aids in sport. *Nutrition Hospitalaria*, *34* (1), 204–215. DOI: 10.20960/nh.997.

Saunders, B., Elliott-Sale, K., Artioli, G.G., Swinton, P.A., Dolan, E., Roschel, H., Gualano, B. (2017). Beta-alanine supplementation to improve exercise capacity and performance: A systematic review and meta-analysis. *British Journal of Sports Medicine*, *51* (8), 658–669. DOI: 10.1136/bjsports-2016-096396.

Savino, G., Valenti, L., D'Alisera1, R., Pinelli, M., Persi, T., Trenti, T. (2019). Dietary supplements, drugs and doping in the sport society. *Annali di igiene: medicina preventica e di comunita*, *31* (6), 548–555. DOI: 10.7416/ai.2019.2315.

Sparks, I.M., Janse van Rensburg, D.C., Fletcher, L., Jansen van Rensburg, A. (2018). A cross-sectional study of 2550 amateur cyclists shows lack of knowledge regarding relevant sports nutrition guidelines. *The South African Journal of Sports Medicine*, *30* (1), 1–6. DOI: 10.17159/2078-516X/2018/v30i1a2963.

Supplements | Australian Institute of Sport (ais.gov.au).

Thielecke, F., Blannin, A. (2020). Omega-3 fatty acids for sport performance—are they equally beneficial for athletes and amateurs? A narrative review. *Nutrients*, *12* (12), 3712. DOI: 10.3390/nu12123712.

Trexler, E.T., Smith-Ryan, A.E., Stout, J.R., Hoffman, J.R., Wilborn, C.D., Sale, C., Kreider, R.B., Jäger, R., Earnest, C.P., Bannock, L., Campbell, B., Kalman, D., Ziegenfuss, T.N., Antonio, J. (2015). International society of sports nutrition position stand: Beta-Alanine. *Journal of International Society of Sports Nutrition*, *12*, 30. DOI: 10.1186/s12970-015-0090-y.

Urdampilleta, A., Gómez-Zorita, S. (2014). From dehydration to hyperhidration isotonic and diuretic drinks and hyperhydratant aids in sport. *Nutriction Hospitalaria*, *29* (1), 21–25. DOI: 10.3305/nh.2014.29.1.6775.

Valenta, R., Dorofeeva, Y.A. (2018). Sport nutrition: the role of macronutrients and minerals in endurance exercises. *Foods and Raw Materials*, *6* (2), 403–412. DOI: 10.21603/2308-4057-2018-2-403-412.

Van Dusseldorp, T.A., Escobar, K.A., Johnson, K.E., Stratton, M.T., Moriarty, T., Cole, N., McCormick, J.J., Kerksick, Ch.M., Vaughan, R.A., Dokladny, K., Kravitz, L., Mermier, Ch.M. (2018). Effect of branched-chain amino acid supplementation on recovery following acute eccentric exercise. *Nutrients*, *10* (10), 1389. DOI: 10.3390/nu10101389.

Venkatraman, J.T., Leddy, J., Pendergast, D. (2000). Dietary fats and immune status in athletes: clinical implications. *Medicine & Science in Sports & Exercise*, *32* (Suppl 7), 389–395. DOI: 10.1097/00005768-200007001-00003.

Vitale, K., Getzin, A. (2019). Nutrition and supplement update for the endurance athlete: review and recommendations. *Nutrients*, *11* (6), 1289. DOI: 10.3390/nu1106128.

Volf, E., Simakova, I., Eliseev, Y., Perkel, R., E. Malyshev, E., Zinin, A. (2020). Quality and safety problems of sports nutrition products. *Agronomy Research*, *18* (3), 1888–1896. DOI: 10.15159/AR.20.092.

Waldron, M., Whelan, K., Jeffries, O., Burt, D., Howe, L., Patterson, S.D. (2017). The effects of acute branched-chain amino acid supplementation on recovery from a single bout of hypertrophy exercise in resistance-trained athletes. *Applied Physiology, Nutrition and Metabolism*, *42* (6), 630–636. DOI: 10.1139/apnm-2016-0569.

Ward, W.E., Chilibeck, F.D., Comelli, E.M., Duncan, A.M., Phillips, S.M., Lindsay E. Robinson, L.E., Stellingwerf, T. (2019). Research in nutritional supplements and nutraceuticals for health, physical activity, and performance: moving forward. *Applied Physiology, Nutrition and Metabolism*, *44* (5), 455–460. DOI: 10.1139/apnm-2018-0781.

Whitehouse, G., Lawlis, T. (2017). Protein supplements and adolescent athletes: A pilot study investigating the risk knowledge, motivations and prevalence of use. *Nutrition & Dietetics*, *74* (5), 509–515. DOI: 10.1111/1747-0080.12367.

Williams, C., Rollo, I. (2015). Carbohydrate nutrition and team sport performance. *Sports Medicine*, *45* (Suppl 1), 13–22. DOI: 10.1007/s40279-015-0399-3.

Williams, M.H. (2004). Dietary supplements and sports performance: introduction and vitamins. *Journal of International Society and Sports Nutrition*, *1* (2), 1–6. DOI: 10.1186/1550-2783-1-2-1.

Wójcicki, K. (2020). FTIR spectroscopy for quality evaluation of sports supplements on the Polish market. *Foods and Raw Materials*, *8* (1), 177–185. DOI: 10.21603/2308-4057-2020-1-177-185.

Zeppa, S.D., Agostini, D., Gervasi, M., Annibalini, G., Amatori, S., Ferrini, F., Sisti, D., Piccoli, G., Barbieri, E., Sestili, P., Stocchi, V. (2020). Mutual interactions among exercise, sport supplements and microbiota. *Nutrients*, *12* (1), 17. DOI: 10.3390/nu12010017.

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THE EFFECTS OF DIFFERENT EXERCISE INTENSITIES ON THE STATIC AND DYNAMIC BALANCE OF OLDER ADULTS: A RANDOMISED CONTROLLED TRIAL

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Abstract This study aims to find the effectiveness of different exercise intensities (high-, moderate-, and low-intensity) on the dynamic and static balance of elderly women. A single-blinded factorial design study was conducted in healthy older adults (>65 years) in 12 weeks. The authors have assessed the Forward Reach Test (FRT), Lateral Reach Test (LRT), One Leg Stand (OLS), Tandem Stand Test (TST) in 60 healthy older women at a gym centre, Fit House located in Bukit Rimau, Kuala Lumpur, Malaysia. Participants were randomly assigned to a High-Intensity Training (HIT) group; (n=15) (Mean age 69.60 ± 3.68) who performed four exercises [Leg Press (LP), Leg Extension (LE), Leg Curl (LC), and Calf Raises (CR)] at 80 to 90% of One-Repetition Maximum (1RM); Moderate-Intensity Training (MIT) group (n=15) (Mean age 69.27 ± 3.41) performed at 65 to 75% of 1RM; Low-Intensity Training (LIT) group (n=15) (Mean age 69.27 ± 1.94) performed at 50 to 60% of 1 RM; and a Control Group (CG) (n = 15) (Mean age 68.67 ± 2.38) with no training. Data was collected at pre-test, 4th, 8th, and 12th weeks of intervention. 60 participants were analysed and the main effect of time showed a statistically significant difference in the mean of all variables (all $p < 0.001$), and also there was a statistically significant interaction between intervention and time on all variables (all $p < 0.001$). Different levels of intensity on only the lower extremities muscles had a significant effect on the dynamic balance and static balance of the elderly population. After four weeks of training HIT, MIT, and LIT illustrated significant improvement in dynamic balance, as well as static balance.

Keywords elderly, resistance training, high-intensity training, moderate-intensity training, low-intensity training, static balance, dynamic balance

Introduction

Ageing contributes to a reduction in static balance and dynamic balance. There is evidence that muscular weakness is highly associated with impaired balance and poses an increased risk of falls. Moreover, lower extremity muscle weakness has been identified as the dominant intrinsic fall-risk factor with a five-fold increase in the risk of falling (Rubenstein, 2006). This downward cycle can lead to reduced muscle quality, fatigability, hypertension, heightened disability, increased risk of developing cardiovascular disease, premature mortality, respiratory failure, and an increased risk of fall (Ghaffari et al., 2016; Jaul, Barron, 2017; Park et al., 2020; Wu, Ouyang, 2017). The lack of productivity also increases the chance of low muscle strength which becomes greater at the age of 70 years and above (Tournadre, Vial, Capel, Soubrier, Spine, 2019). Physical inactivity is estimated to be the primary cause of approximately 21 to 25% of breast and colon cancers, 27% of diabetes, and approximately 30% of heart disease worldwide (WHO, 2019).

In this regard, Resistance training (RT) programmes have been widely supported as a major countermeasure to the age-related declines mentioned above. Many studies have emphasised the safety and efficacy of strength training in older people, it is considered as a safe type of exercise for older adults, with hardly any related injuries or any report of adverse events (Aartolahti, Lönnroos, Hartikainen, Häkkinen, 2020; Lichtenberg, Von Stengel, Sieber, Kemmler, 2019; Müller et al., 2020; Sahin et al., 2018; Watson et al., 2015). (Moro et al., 2017; Müller et al., 2020; Sahin et al., 2018) suggest that high-intensity RT can be safely performed by older individuals, and it is also emerging as a safe and effective means to combat chronic diseases (Keating, Johnson, Mielke, Coombes, 2020). When addressing safety in an ageing population, it is always important to note that the intensity of RT (high, moderate, or low) is relative to the participant's level of fitness (Keating et al., 2020).

During the past several years, some organisations have released recommendations concerning RT programmes to provide a framework for training prescription guidelines for individuals of different trainability status, especially for older adults (Fragala et al., 2019; Nascimento, Ingles, Salvador-Pascual, Cominetti, Gomez-Cabrera, Viña, 2019). There have been recommendations that address effective RT to gain muscle strength and mass. RT can produce benefits in strength and balance performance, According to World Health Organization, older adults should participate in moderate intensity activities for minimum 150 minutes in a week and also, they should be involved in a strength resistance activities 2 or more days in a week (WHO, 2010). The Positive effects of RT has been reported by (Amarante et al., 2020) even after detraining the older women can regain the RT program benefits and (Marques, Figueiredo, Harris, Wanderley, Carvalho, 2017) reported that there was a significant improvement after RT training in old women. But the distribution of the training intensities must be carefully investigated and planned. However, there is a lack of information about what type of intensity can help the elderly to improve stability factors such as dynamic and static balance, to be faster and more effective (Cobbold, 2018; Marcos-Pardo et al., 2019). There have only been a few studies related to RT intensity so therefore this question has yet to be solved regarding the effectiveness of different intensities. Therefore, this current study is aimed at comparing the effects of 12-week different exercise intensities on balance factors of healthy older women. The hypothesis was that higher intensity training would be more effective in the 4th, 8th, and 12th weeks of intervention.

Materials and Methods

Study design

A single blinded factorial design randomised controlled trial has been conducted in healthy older adults at a gym centre, Fit House located in Bukit Rimau, Kuala Lumpur, Malaysia, from November 2019 till January 2020. All participants were informed about the experimental procedures and potential risks before they provided their written informed consent. The investigation was conducted according to the Declaration of Helsinki and was approved by the University Putra Malaysia Interior Research Ethics Committee (JKEUPM-2018-333), (Trial Registration: NCT04901520). In addition, this randomised clinical trial was designed according to CONSORT guidelines (https://www.consort-statement.org/).

Participants

Sample size estimation was conducted using G*Power version 19. An effect size of 0.25 level of 0.05 and a Power (1-β err prob) of 0.95 indicated that it would be necessary to include at least 52 volunteers (15 subjects per group). According to 15% possibility of dropout, according to 15% possibility dropout, 60 participants in this study were participated. The sample was primarily selected through interview or clinical referrals. The inclusion criteria were that subjects should be 65 years old and above, able to follow the simple instructions, and perform the exercises, without any health problems that would possibly interfere their safety or ability to complete High Intensity Training (HIT), Moderate Intensity Training (MIT) and Low Intensity Training (LIT).The exclusion criteria such as the occurrence of myocardial infarction in the past six months, recent heart attack, uncontrolled hypertension (Blood Pressure >166/96 mm Hg), broken leg in the past six months, diagnosed osteoporosis, and diagnosed stage three or four of heart failure, not participating in regular balance or lower body RT during the past three months and not taking regular medication that could impair balance ability (Antidepressants, Neuroleptics or Benzodiazepines) or muscle strength (Corticosteroids). Sixty healthy Malaysian elderly women (age range: 65 to 76 years old) were eligible to participate in this study. The data was measured as Mean ± *SD.* After an initial evaluation, the participants were randomly assigned to four groups: HIT (n = 15), MIT (n = 15), LIT (n = 15), and CG (n = 15) by a computerised random-number generator (See Figure 1). The process of randomisation was carried out by a blinded researcher who was not affiliated with the study.

Researcher obtained their signature for consent forms from all the participants. All the participants were blinded regarding their group allocation, and they completed the entire study. If any participants could not join the training session, then an alternative session in the same week was arranged for them and all the training sessions were conducted in the Fitness Centre in Atria Shopping Mall located in Petaling Jaya, Kuala Lumpur. The characteristics of the subjects are displayed in Table 1.

Table 1. Demographic Characteristics at baseline

Demographic Characteristics	HIT (N = 15)	MIT (N = 15)	LIT (N = 15)	CG (N = 15)	P-Value*
Age	69.60 (3.68)	69.27 (3.41)	69.27 (1.94)	68.67 (2.38)	0.85
Height (cm)	167.28 (3.50)	166.34 (5.24)	166.60 (3.20)	167.17 (3.85)	0.91
Weight (kg)	77.86 (5.76)	75.60 (5.61)	75.68 (4.55)	75.26 (5.25)	0.52
BMI (kg/m^2)	28.01 (1.23)	27.50 (1.94)	26.70 (2.15)	26.74 (1.47)	0.12

Data is presented as mean ± SD.

* Obtained from the one-way analysis of variance (ANOVA).

Abbreviations: N = Number of subjects; M = Mean; SD = Standard Deviation; HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; BMI= Body Mass Index; FM= Fat Mass; FFM= Fat Free Mass.

Measurements

Anthropometry: Upon arriving at the training location, the subjects were instructed to empty their bladders within 30 minutes of anthropometric measurements. Body mass was measured to the nearest 0.1 kg using a calibrated electronic scale (Omron Body Composition Monitor Weighing) (KYOTO, 617-0002 JAPAN) (Jensky-Squires, Dieli-Conwright, Rossuello, Erceg, McCauley, Schroeder, 2008), with the subjects wearing light workout clothing and no shoes. Height was measured to the nearest 0.1 cm with a stadiometer attached on the scale with subjects standing with no shoes. Body mass index (BMI) was calculated as body mass in kilograms divided by the square root of the height in metres.

Dynamic Balance: Lateral Reach Test (LRT) and Forward Reach Test (FRT) tests were used to measure dynamic balance.

a) ***FRT*** *is taken as* the maximum length that a person might reach forward beyond arm's length while maintaining a stable standing position (Costarella, Monteleone, Steindler, Zuccaro, 2010). To measure this test, it is required to mount a measuring tape on the wall nearly at the shoulder height of the subject. The subject will stand next to, but not touching, the wall and elevate the arm that is nearer to the wall to 90 degrees shoulder flexion with a closed fist. After that, the subject should lean forward along the yardstick as far as possible without losing balance or taking a step. The distance will be measured in centimetres on the measuring tape. Each subject performed one practice and two trials that the longest score of two trials was recorded.

b) Older Adults often experience lateral falls. Therefore, it is necessary to test the lateral stability to identify fall risk (Takahashi et al., 2006). *To measure the **LRT***, the subject was asked to stand straight near and with the back against the wall. They were instructed to elevate the arm to 90 degrees shoulder and reach sideward as far as possible through the measuring tape mounted on the wall without losing balance, taking a step, or touching the wall with a dominant hand. The feet should remain completely in contact on the floor throughout the test. Each subject should maintain the maximal lateral reach position for three seconds before coming back to the initial position. Each subject performed one practice trial for familiarisation and two test trials. The best performance score of two trials was recorded.

Static Balance: To measure the static balance, Tandem Stand Test (TST) and One Leg Stand (OLS) was performed. The subjects performed one practice and two trials for each test, and the average time from the two trials was reported.

a) ***TST*** is an accepted clinical measurement of standing balance (Bergquist et al., 2019). To measure this test, the subject places the heel of one foot in front of and touching the big toe of the other foot in a straight line. The tester will demonstrate the tandem stance position and then instruct the participant to stay in this position and maintain it for a maximum of 30 seconds without losing balance or taking a step. The duration was measured by a stopwatch.

b) ***OLS*** is usually used for measuring postural stability in the elderly (Leirós-Rodríguez, Romo-Pérez, García-Soidán, 2017; Motalebi, Cheong, Iranagh, Mohammadi, 2018). The ability to stand on one leg needs to move the centre of mass towards the standing leg as well as preserving postural alignment in the space. This task demands control of body weight, the upright alignment of all the body parts and a sense of equilibrium. The OLS evaluates the static balance through the number of seconds when a person might preserve the one-leg position. It is assumed that people with higher postural steadiness can stand for a longer time on one leg. In the current study, the maximum OLS duration was 30 seconds based on Bohannon's ordinal balance assessment scale.

In this test, a subject should take the back of a chair and stand on the preferred leg and then take the hands off the chair and control their balance on one leg without any support for a maximum of 30 seconds. The time was measured by a digital stopwatch. Each subject performed one-time practice and two trials, and the average time for the two trials was reported.

Procedures

The total duration of the study was 14 weeks, of which the first 2 weeks (1 to 2 weeks) were used for familiarisation with the RT programme exercises and pre-training measures, and after 12 weeks of intervention a post-training measurement was performed. A supervised progressive RT programme was undertaken between weeks 2 to 14. Training was performed twice per week during the morning hours (8 to 9 AM). The protocol was based on RT recommendations for the older population to improve muscle endurance and muscular strength. All subjects were personally supervised by physical education professionals with substantial RT experience to ensure consistent and safe performance.

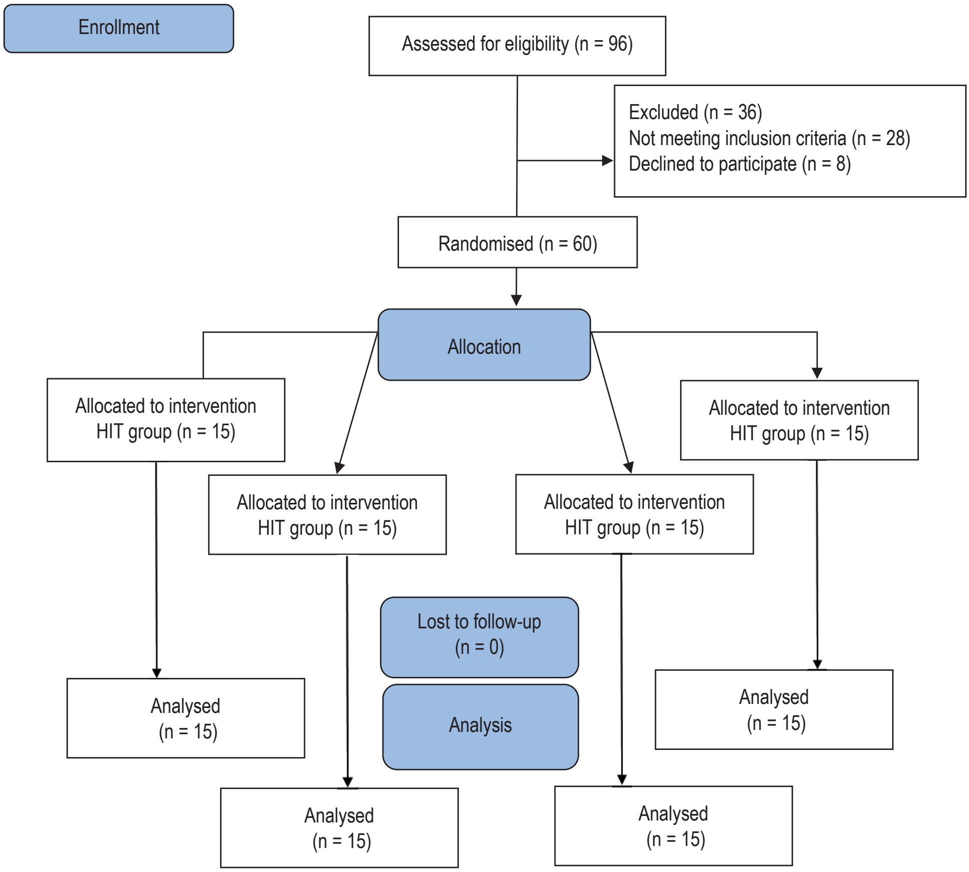
Subjects performed different intensities RT using machines. The RT programme was a lower extremity programme with four exercises performed in the following order: Leg Press (LP), Leg Extension (LE), Leg Curl (LC), and Calf Raises (CR). The intensity of the strength training in this study was determined individually by an indirect method to evaluate One Repetition Maximum (1 RM): after a couple of introductory training sessions, the prediction of training load was evaluated using 3 to 6 repetitions (Bechshøft et al., 2017). A 3 to 6 RM test was chosen because it was suitable to test maximal strength in subjects with little or no previous resistance training experience (Liguori et al., 2020), and this technique has been shown to have a high reproducibility ($r = 0.99$) in the laboratory (Paoli et al., 2013). Using the results of the strength testing, 1RMs were estimated with the Brzycki formula: 1 RM (estimated) = load (kg) / [1.0278 − (0.0278 × number of repetitions)].

After calculating the 1 RM, participants were randomly assigned to the experimental groups performing different intensity RTs, while those assigned to the Control Group (CG) merely undertook daily-life activities (without training). All experimental groups performed the RT programme twice a week for 12 weeks. HIT group trained with 80 to 90% of their 1RM, the MIT group 65 to 75% of their 1RM and the LIT group (50 to 60% of their 1RM). RT was the same across the experimental groups, consisting of LP, LE, LC, and CR which was designed based on recent pieces of evidence.

All subjects were evaluated in one session. Before the testing session, the anthropometric measurement had been taken. During the testing session, the participants performed the following: FRT, LRT, OLS, TST. During the two weeks preceding this study, four preliminary familiarisation sessions were undertaken to ensure a properly executed technique in all exercises by all participants. To evaluate the effectiveness of different intensities, the same tests were performed after the 4th, 8th, and 12th weeks of training. Throughout this period, the participants were asked to refrain from participating in regular exercise programmes outside the study aimed at developing or maintaining strength.

Subjects were instructed to inhale during the eccentric muscle action and exhale during the concentric muscle action while maintaining a constant velocity of movement at a ratio of 1 : 2 (concentric and eccentric muscle actions, respectively). Subjects were afforded a 2 to 3-minute rest between each exercise. The instructors adjusted the loads of each exercise according to the ability of the subjects and improvements in exercise capacity throughout the study to ensure that they were exercising with as much resistance as possible while maintaining proper exercise execution technique. Progression was planned if the subject could perform full sets and repetitions such that the weight was increased 5 to 10% in the next training session. During both RT phases, instructors registered the load (in kilograms) and repetitions performed for each of the four exercises from all subjects during each session. All subjects were asked to maintain their normal diet throughout the study period.

Figure 1. Study Flow Diagram



Statistical Analysis

The normality of the data from the study was confirmed using the Shapiro–Wilk test and Q-Q plots. Possible group differences at the baseline were examined using a one-way analysis of variance (ANOVA). A time (baseline, 4th, 8th, and 12th weeks) × group (HIT vs. MIT vs. LIT vs. CG) factorial ANOVA with repeated measures was performed to determine differences between the treatments and also the multivariate analysis of variance (ANOVA) was performed to find the effect of two tests on one variable. A two-way analysis of covariance (ANCOVA) for repeated measures was performed with the baseline scores used as a covariate to eliminate any possible influence of initial score variances on training outcomes (Van Breukelen, 2006; Vickers, Altman, 2001). While the raw unadjusted and ANCOVA-adjusted data for main outcomes was presented, statistical interpretations were made from the ANCOVA-adjusted results. This was followed by the appropriate Bonferroni and Tukey post hoc test when a significant treatment and treatment-by-time interaction was revealed. In variables where the sphericity was violated as indicated by the Mauchly test, the analyses were adjusted using a Greenhouse-Geisser correction. The effect size partial eta squared (η2) was used for comparisons of effects within the study. Statistical significance was set at P < 0.05. IBM SPSS (version 26, IBM) was used to analyse the data.

Results

Overall compliance of subjects to the RT programme was 100% as a replacement session was arranged if a subject could make any of the sessions and also there were no dropouts during the study. There were no significant differences between groups for age, body mass, height, BMI, FRT, LRT, OLS, and TST, at baseline (P > 0.05). Assessments were done at baseline, 4th, 8th, and 12th weeks of interventions, and the results presented in Table 2. No adverse events were reported during testing or training in all groups. There were only a few reports regarding muscle soreness in the first two weeks of training.

Dynamic Balance:

FRT: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each treatment level illustrated that there was a statistically significant difference between times at each treatment level except for the CG. The effect of time in all groups showed that all pairwise comparisons for the intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that, HIT compared with LIT at 12th week (P < 0.001) of intervention, HIT compared with CG at 8th week (P < 0.001) and 12th week (P < 0.001) of intervention was statistically significant. MIT compared with CG at 8th week (P = 0.007), 12th week (P < 0.001) of intervention was statistically significant. LIT compared with CG at 12th week (P = 0.005) of intervention was statistically significant. (See Figure 1).

LRT: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each treatment level illustrated that there was a statistical significance between times at each treatment level except for the CG. The effect of time in all groups showed that all pairwise comparisons for intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that HIT compared with MIT at 12th week (P < 0.001) of intervention, HIT compared with LIT at 8th week (P = 0.001) and 12th week (P < 0.001) of intervention, HIT compared with CG at 4th week (P < 0.001), 8th week (P < 0.001), and 12th week (P < 0.001) of intervention was statistically significant. MIT compared with LIT at 4th week, 8th weeks, 12th week of intervention was not statistically significant. MIT compared with CG at 4th week (P = 0.004), 8th week (P < 0.001), 12th week (P < 0.001) of intervention was statistically significant. Also, LIT compared with CG at 4th week (P = 0.011), 8th week (P < 0.001), 12th week (P < 0.001) of intervention was statistically significant (See Figure 1).

The authors attempted to understand the overall effects of FRT, and LRT on dynamic balance, as such the multivariate analysis of variance (ANOVA) was undertaken for both test and the results presented in Table 3. The authors found there was a significant effect of different intensity training on dynamic balance (P < 0.001, = 0.847) and also when the baseline value outcomes were adjusted (P < 0.001, = 0.848).

Static Balance:

OLS: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each treatment level illustrated that there was a statistical significance between times at each treatment level except for the CG. The effect of time in all groups showed that all pairwise comparisons for the intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that only HIT compared with CG at 12th week ($P = 0.021$) of intervention was statistically significant. MIT compared with LIT at 4th week, 8th week and 12th week of intervention were not statistically significant. MIT compared with CG at 12th week ($P = 0.038$) of intervention, LIT compared with CG at 12th ($P = 0.047$) week of intervention was statistically significant. (See Figure 1).

TST: The mean comparison between groups at different time points is shown in Table 2. The effect of time at each intensity level illustrated that there was a statistically significant difference between the times at each treatment level except the CG. The effect of time in all groups showed that all pairwise comparisons for intervention groups were statistically significant. The opposite of the other groups, pairwise comparisons were not statistically significant in the repeated times of the CG. The tests of treatment at each tie point (times) were performed and the result of pairwise comparisons indicated that HIT compared with CG at 8th week ($P = 0.007$) and 12th week ($P < 0.001$) of intervention is statistically significant. MIT compared with LIT at 4th week, 8th week, and 12th week of intervention was not statistically significant. MIT with CG 8th week ($P = 0.007$), and 12th week ($P < 0.001$) of intervention, LIT compared with CG at 8th week ($P = 0.023$), and 12th week ($P = 0.002$) of intervention was statistically significant (See Figure 1).

The authors attempted to understand the overall effects of OLS, and TST on static balance, as such the multivariate analysis of variance (ANOVA) was performed for both test and the result as presented in Table 3. It was found that there was a significant effect of different intensity training on dynamic balance ($P < 0.001$, = .765) and when the baseline value outcomes were adjusted ($P < 0.001$, = .766).

Figure 2. Comparison between HIT, MIT, LIT and CG at baseline, 4th, 8th, and 12th week of intervention

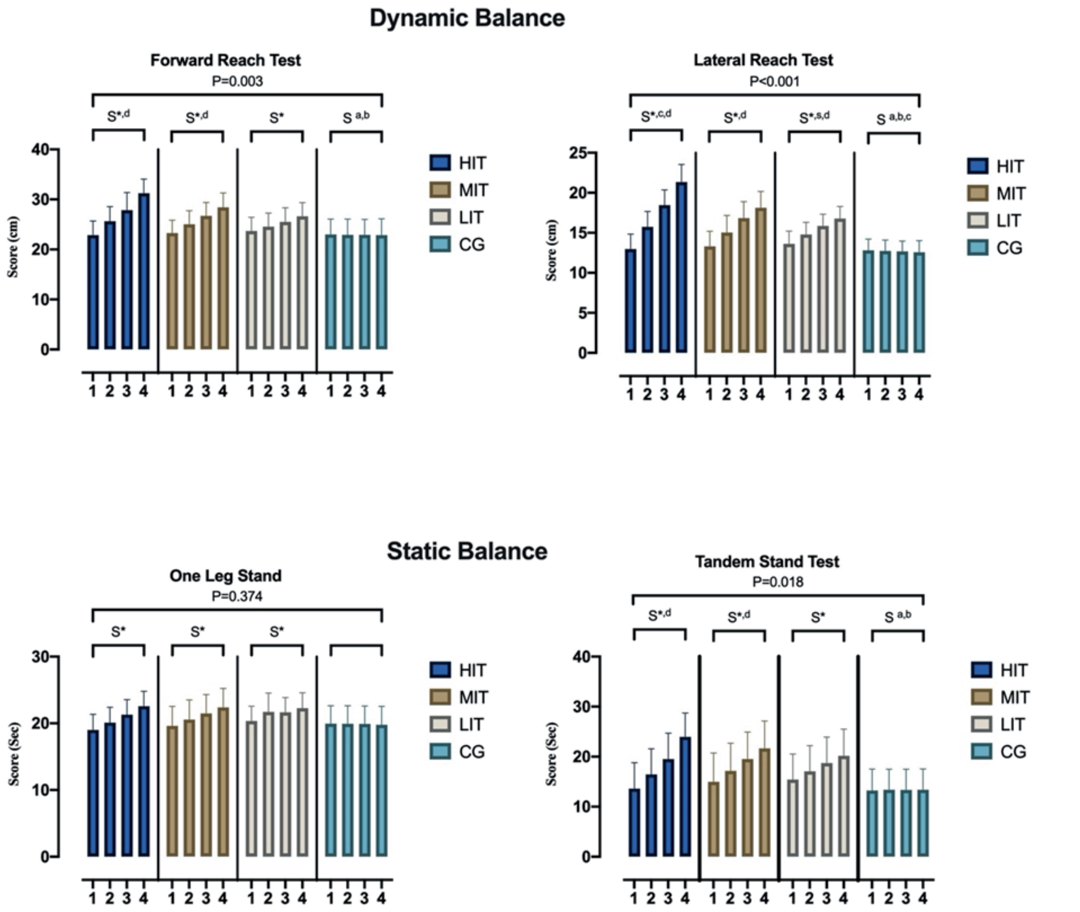


Table 2. The effect of different intensity training on different variables among study participants after 4th, 8th, and 12th week of intervention

		Baseline	4th week	8th week	12th week	Change	P-Value* (partial eta square)		
							Time	Group	Time*group
FRT							<0.001 (.85)	0.003 (.22)	<0.001 (.76)
	HIT	22.83 (2.81)	25.65 (2.89)	27.86 (3.51)	31.23 (2.83)	8.38 (.64)[d]			
	MIT	23.28 (2.56)	25.04 (2.71)	26.70 (2.69)	28.42 (2.87)	5.14 (1.02)[d]			
	LIT	23.70 (2.71)	24.56 (2.71)	22.52 (2.80)	26.63 (2.73)	2.93 (.47)			
	CG	22.99 (3.08)	22.91 (3.15)	22.90 (3.10)	22.85 (3.25)	–0.14 (.53)[a,b]			
LRT							<0.001 (.96)	<0.001 (.48)	<0.001 (.94)
	HIT	12.69 ±1.87	15.75 ±1.91	18.46 ±1.90	21.34 ±2.18	8.38 (.72)[c,d]			
	MIT	13.30 ±1.88	15.04 ±2.12	16.82 ±2.07	18.13 ±2.04	4.83 (.63)[d]			
	LIT	13.61 ±1.59	14.79 ±1.51	15.84 ±1.48	16.78 ±1.50	3.17 (.43)[a,d]			
	CG	12.81 ±1.40	12.72 ±1.36	12.67 ±1.29	12.57 ±1.44	–0.24 (.49)[a,b,c]			
OLS							<0.001 (.63)	0.374 (.05)	<0.001 (.47)
	HIT	19.00 ±2.35	20.10 ±2.30	21.28 ±2.28	22.56 ±2.21	3.56 (.32)			
	MIT	19.58 ±2.94	20.53 ±2.95	21.44 ±2.84	22.35 ±2.86	2.76 (.30)			
	LIT	20.34 ±2.21	21.71 ±2.81	21.64 ±2.22	22.28 ±2.30	1.93 (.30)			
	CG	19.94 ±2.69	19.92 ±2.71	19.90 ±2.68	19.78 ±2.75	–0.15 (.64)			
TST							<0.001 (.85)	0.018 (.16)	<0.001 (.73)
	HIT	13.60 ±5.19	16.44 ±5.11	19.53 ±5.15	23.94 ±4.78	10.34 (3.75)[d]			
	MIT	14.96 ±5.75	17.15 ±5.53	19.51 ±5.39	21.64 ±5.48	6.68 (.82)[d]			
	LIT	15.41 ±5.12	17.06 ±5.15	18.72 ±5.17	20.18 ±5.33	4.76 (.48)			
	CG	13.24 ±4.27	13.36 ±4.12	13.35 ±4.12	13.37 ±4.18	0.12 (0.56)[a,b]			

[a] Significant compared to HIT.
[b] Significant compared to MIT.
[c] Significant compared to LIT.
[d] Significant compared to CG.
*Obtained from the two-way (mixed) repeated measures (ANOVA).
Abbreviations: HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; FRT = Forward Reach Test; LRT = Lateral Reach Test; OLS = One Leg Stand Test; TST = Tandem Stand Test.

Table 3. Crude mean changes of outcome variables throughout the trial in the HIT, MIT, LIT, and CG

			HIT	MIT	LIT	CG	P-Value	Partial eta square
1	2	3	4	5	6	7	8	9
Dynamic Balance**								
	Crude						<0.001	0.847
		FRT	8.38 ±0.64[b,c,d]	5.14 ±1.02[a,c,d]	2.93 ±0.47[a,b,d]	–0.14 ±0.53[a,b,c]	<0.001	0.955
		LRT	8.38 ±0.72[b,c,d]	4.83 ±0.63[a,c,d]	3.17 ±0.43[a,b,d]	–0.24 ±0.49[a,b,c]	<0.001	0.968
	Adjusted[b]						<0.001	0.848
		FRT	8.39 ±0.18[b,c,d]	5.13 ±0.18[a,c,d]	2.90 ±0.18[a,b,d]	–0.11 ±0.18[a,b,c]	<0.001	0.955

1	2	3	4	5	6	7	8	9
		LRT	8.37 ±0.15[b,c,d]	4.83 ±0.15[a,c,d]	3.17 ±0.15[a,b,d]	–0.23 ±0.15[a,b,c]	<0.001	0.968
Static Balance **								
	Crude						<0.001	0.765
		OLS	3.56 ±0.32[b,c,d]	2.76 ±0.30[a,c,d]	1.93 ±0.30[a,b,d]	–0.15 ±0.64[a,b,c]	<0.001	0.921
		TST	10.34 ±3.75[b,c,d]	6.68 ±0.82[a,d]	4.76 ±0.48[a,d]	0.12 ±0.56[a,b,c]	<0.001	0.791
	Adjusted[e]						<0.001	0.766
		OLS	3.54 ±0.11[b,c,d]	2.76 ±0.11[a,c,d]	1.95 ±0.11[a,b,d]	–0.15 ±0.11[a,b,c]	<0.001	0.920
		TST	10.28 ±0.50[b,c,d]	6.74 ±0.49[a,d]	4.87 ±0.50[a,d]	0.01 ±0.50[a,b,c]	<0.001	0.801

Data is presented as mean ± SE.
Changes obtained through this formula: Final – Baseline.
* Obtained from the Univariate Analysis of Variance (ANOVA).
** Obtained from Multivariate Analysis of Variance (ANOVA).
[a] Significant compared to HIT.
[b] Significant compared to MIT.
[c] Significant compared to LIT.
[d] Significant compared to CG.
[e] Adjust for baseline values.
Abbreviations: HIT = High Intensity Training; MIT = Moderate Intensity Training; LIT = Low Intensity Training; CG = Control Group; FRT = Forward Reach Test; LRT = Lateral Reach Test; OLS = One Leg Stand Test; TST = Tandem Stand Test.

Discussion

Although there have been some studies where an experiment was conducted to determine the effect of different intensity RT on static and dynamic balance, to the best of our knowledge the present experiment is the first study to assess HIT, MIT, LIT and CG at the same time to find their exact effect and also to have a better understanding of their role in the body at different time points.

The main study objective was to compare the effects of different RT intensities on dynamic balance, and static balance of elderly women. The data was collected at the 4th, 8th, and 12th week of intervention. All experimental groups showed improvements in the assessed variables, specifically the FRT, LRT, OLS, and TST. Furthermore, HIT (80 to 90% 1RM) seemed to be more effective than MIT (65 to 75% 1RM), LIT (50 to 60% 1RM) and CG (no training) for improvement in FRT, LRT, and TST at different time points, but there was no difference between groups in OLS. These findings reveal that although all the RT intensities resulted in improvements, the HIT tended to result in higher gains after the 4th, 8th, and 12th week of training.

Previous studies reported the effects of different RT variables on dynamic and static balance. Progressive RT (Cancela Carral, Rodríguez, Cardalda, Gonçalves Bezerra, 2019; Marques et al., 2011; Martins et al., 2011), home-based training (Sparrow, Gottlieb, Demolles, Fielding, 2011) and also different intensity training (Marques et al., 2011; Nicklas, Chmelo, Delbono, Carr, Lyles, Marsh, 2015; Ramirez-Campillo et al., 2018; Shiotsu, Yanagita, 2018; Sparrow et al., 2011) have been shown to be effective to improve balance in elderly and even in home-dwelling hip fracture patients (Sylliaas, Brovold, Wyller, Bergland, 2011; Berg, Stutzer, Hoff, Wang, 2021).

The result of this study is in line with many previous studies that examined the effects of RT on the elderly population. In a study by Shiotsu, Yanagita (2018) those authors found greater dynamic balance improvement in a group who combined aerobic training with moderate intensity RT compared to aerobic and low-intensity RT. In addition, Ramirez-Campillo et al. (2018) concluded that two and three training sessions per week of RT with 75%

1RM were effective for improving balance in older women. In a 32-week study by Marques et al. (2011), the intensity of the training after two weeks was adjusted to 75 % to 80 % of 1 RM at a working range of six to eight repetitions for two sets and those authors found that 8 months RT could elicit significant gains in balance with moderate to high intensity compared to aerobic training and no training. Significant improvement in balance was found in the patients with hip fracture after three months of high-intensity RT (Sylliaas et al., 2011). In that study the authors studied the patients for 12 weeks and subjects trained three times per week with 70% (first three weeks) and 80% (for rest of the study) intensity and repetition dropped from 12 to 8. Those authors found a significant improvement in balance compared to the CG in the study. Along with different intensity training, some studies reported that RT generally could be effective to improve dynamic and static balance. Also Nicklas et al. (2015) looked to find balance improvements in RT with and without calorie restriction. They studied overweight and obese elderly and the subjects participated in the intervention for 20 weeks and three times per week with an intensity of 70% 1RM. Both RT and RT with calorie restriction improved balance significantly, which suggested that even with calorie restriction RT can be effective to improve balance.

As the current authors expected in this study, the result supported the previous studies that examined the different RT intensities concerning balance. It is worth noting that different studies have linked an increase in muscle strength to an increase in the ability to balance in the elderly (Lacroix et al., 2016; Lee, Park, 2013; Marques et al., 2017). This was likely due to the intrinsic factors associated with ageing, such as degenerative processes in the nervous and muscular systems that lead to muscle weakness and gait instability (Rubenstein, 2006). Hence also in this study an improvement in muscle strength as well as static and dynamic balance was observed which can support the previously mentioned studies.

Conclusion

Different levels of intensity on only lower extremities muscles have a significant effect on dynamic balance and static balance of the elderly population. After 4 weeks of training HIT, MIT, and LIT illustrated significant improvement in dynamic balance, as well as static balance. This result showed that even short-term lower body muscle strength training can be effective in the older population to increase their balance ability. The result was repeated at 8 and 12 weeks of training. HIT was found to be more effective than MIT, and MIT was more effective than LIT. However, LIT was more effective than no training in all at the three different time points (4, 8, and 12 weeks). Given the importance of RT for older adults, it was promising to note that the current intervention did not report any adverse events. This confirms the previous findings that HIT, MIT and LIT is feasible and safe for older adults.

Practical Applications

The results suggested that performing different intensity training may be beneficial for balance development in healthy older women. Furthermore, choosing HIT can be more beneficial in these variables compared to MIT, LIT, and no training. These findings should be considered useful to design RT programmes for healthy elderly women to gain their functional factors faster in a shorter time.

References

Aartolahti, E., Lönnroos, E., Hartikainen, S., Häkkinen, A. (2020). Long-term strength and balance training in prevention of decline in muscle strength and mobility in older adults. *Aging Clinical and Experimental Research*, *32* (1), 59–66. DOI: 10.1007/s40520-01901155-0.

Amarante do Nascimento, M., Nunes, J. P., Pina, F. L. C., Ribeiro, A. S., Carneiro, N. H., Venturini, D., Cyrino, E. S. (2020). Comparison of 2 Weekly Frequencies of Resistance Training on Muscular Strength, Body Composition, and Metabolic Biomarkers in Resistance-Trained Older Women: Effects of Detraining and Retraining. *Journal of Strength and Conditioning Research*. DOI: 10.1519/jsc.0000000000003799.

Bechshøft, R.L., Malmgaard-Clausen, N.M., Gliese, B., Beyer, N., Mackey, A.L., Andersen, J.L., Kjær, M., Holm, L. (2017). Improved skeletal muscle mass and strength after heavy strength training in very old individuals. *Experimental Gerontology*, *92*, 96–105. DOI: 10.1016/j.exger.2017.03.014.

Berg, O.K., Stutzer, J.M., Hoff, J., Wang, E. (2021). Early Maximal Strength Training Improves Leg Strength and Postural Stability in Elderly Following Hip Fracture Surgery. *Geriatric Orthopaedic Surgery & Rehabilitation*, *12*, 21514593211015103. DOI: 10.1177%2F21514593211015103.

Bergquist, R., Weber, M., Schwenk, M., Ulseth, S., Helbostad, J. L., Vereijken, B., Taraldsen, K. (2019). Performance-based clinical tests of balance and muscle strength used in young seniors: A systematic literature review. BMC *Geriatrics*, *19* (1), 9. DOI: 10.1186/s12877018-1011-0.

Cancela Carral, J.M., Rodríguez, A.L., Cardalda, I.M., Gonçalves Bezerra, J.P.A. (2019). Muscle strength training program in nonagenarians – a randomized controlled trial. *Revista Da Associacao Medica Brasileira*, *65* (6), 851–856. DOI: 10.1590/1806-9282.65.6.851.

Cobbold, C. (2018). Battle of the sexes: Which is better for you, high-or low-intensity exercise?. *Journal of sport and health science*, *7* (4), 429. DOI: 10.1016/j.jshs.2018.05.004.

Costarella, M., Monteleone, L., Steindler, R., Zuccaro, S. M. (2010). Decline of physical and cognitive conditions in the elderly measured through the functional reach test and the mini mental state examination. *Archives of gerontology and geriatrics*, *50* (3), 332–337. DOI: 10.1016/j.archger.2009.05.013.

Fragala, M.S., Cadore, E.L., Dorgo, S., Izquierdo, M., Kraemer, W.J., Peterson, M.D., Ryan, E.D. (2019). Resistance training for older adults: Position statement from the national strength and conditioning association. *Journal of Strength and Conditioning Research*, *33* (8), 2019–2052. DOI: 10.1519/jsc.0000000000003230.

Ghaffari, S., Pourafkari, L., Tajlil, A., Sahebihagh, M.H., Mohammadpoorasl, A., Tabrizi, J.S., Nader, N. D., Azizi Zeinalhajlou, A. (2016). The prevalence, awareness and control rate of hypertension among elderly in northwest of Iran. *Journal of Cardiovascular and Thoracic Research*, *8* (4), 176–182. DOI: 10.15171/jcvtr.2016.35.

Jaul, E., Barron, J. (2017). Age-related diseases and clinical and public health implications for the 85 years old and over population. *Frontiers in Public Health*, *5*, 335. DOI: 10.3389/fpubh.2017.00335.

Jensky-Squires, N.E., Dieli-Conwright, C.M., Rossuello, A., Erceg, D.N., McCauley, S., Schroeder, E.T. (2008). Validity and reliability of body composition analysers in children and adults. *British Journal of Nutrition*, *100* (4), 859-865. DOI: 10.1017/S0007114508925460.

Keating, S.E., Johnson, N.A., Mielke, G.I., Coombes, J.S. (2017). A systematic review and meta-analysis of interval training versus moderate-intensity continuous training on body adiposity. *Obesity Reviews*, *18* (8), 943–964. DOI: 10.1111/obr.12536.

Lacroix, A., Kressig, R.W., Muehlbauer, T., Gschwind, Y.J., Pfenninger, B., Bruegger, O., Granacher, U. (2016). Effects of a supervised versus an unsupervised combined balance and strength training program on balance and muscle power in healthy older adults: A randomized controlled trial. *Gerontology*, *62* (3), 275–288. DOI: 10.1159/000442087.

Lee, I.H., Park, S.Y. (2013). Balance improvement by strength training for the elderly. *Journal of Physical Therapy Science*, *25* (12), 1591–1593. DOI: 10.1589/jpts.25.1591.

Leirós-Rodríguez, R., Romo-Pérez, V., García-Soidán, J.L. (2017). Validity and reliability of a tool for accelerometric assessment of static balance in women. *European Journal of Physiotherapy*, *19* (4), 243–248. DOI: 10.1080/21679169.2017.1347707.

Lichtenberg, T., Von Stengel, S., Sieber, C., Kemmler, W. (2019). The favorable effects of a high-intensity resistance training on sarcopenia in older community-dwelling men with osteosarcopenia: The randomized controlled frost study. *Clinical Interventions in Aging*, *14*, 2173–2186. DOI: 10.2147/CIA.S225618.

Liguori, G., & American College of Sports Medicine. (2020). *ACSM's guidelines for exercise testing and prescription* (10th ed.). Lippincott Williams & Wilkins.

Marcos-Pardo, P.J., Orquin-Castrillón, F.J., Gea-García, G.M., Menayo-Antúnez, R., González Gálvez, N., Vale, R.G. de S., Martínez-Rodríguez, A. (2019). Effects of a moderate to-high intensity resistance circuit training on fat mass, functional capacity, muscular strength, and quality of life in elderly: A randomized controlled trial. *Scientific Reports*, *9* (1), 1–12. DOI: 10.1038/s41598-019-44329-6.

Marques, E.A., Figueiredo, P., Harris, T.B., Wanderley, F A., Carvalho, J. (2017). Are resistance and aerobic exercise training equally effective at improving knee muscle strength and balance in older women? *Archives of Gerontology and Geriatrics*, *68*, 106–112. DOI: 10.1016/j.archger.2016.10.002.

Marques, E.A., Wanderley, F., Machado, L., Sousa, F., Viana, J.L., Moreira-Gonçalves, D., Moreira, P., Mota, J., Carvalho, J. (2011). Effects of resistance and aerobic exercise on physical function, bone mineral density, OPG and RANKL in older women. *Experimental Gerontology*, *46* (7), 524–532. DOI: 10.1016/j.exger.2011.02.005.

Martins, R.A., Coelho E Silva, M.J., Pindus, D.M., Cumming, S.P., Teixeira, A.M., Veríssimo,M.T. (2011). Effects of strength and aerobic-based training on functional fitness, mood and the relationship between fatness and mood in older adults. *Journal of Sports Medicine and Physical Fitness*, *51* (3), 489–496. PMID: 21904289.

Moro, T., Tinsley, G., Bianco, A., Gottardi, A., Gottardi, G.B., Faggian, D., Plebani, M., Marcolin, G., Paoli, A. (2017). High intensity interval resistance training (HIIRT) in older adults: Effects on body composition, strength, anabolic hormones and blood lipids. *Experimental Gerontology*, *98*, 91–98. DOI: 10.1016/j.exger.2017.08.015.

Motalebi, S.A., Cheong, L.S., Iranagh, J A., Mohammadi, F. (2018). Effect of low-cost resistance training on lower-limb strength and balance in institutionalized seniors. *Experimental Aging Research*, *44* (1), 48–61. DOI: 10.1080/0361073X.2017.1398810.

Müller, D.C., Izquierdo, M., Boeno, F.P., Aagaard, P., Teodoro, J.L., Grazioli, R., Radaelli, R. Bayer, H., Neske, R., Pinto, R.S., Cadore, E.L. (2020). Adaptations in mechanical muscle function, muscle morphology, and aerobic power to high-intensity endurance training combined with either traditional or power strength training in older adults: a randomized clinical trial. *European Journal of Applied Physiology*, *120* (5), 1165–1177. DOI: 10.1007/s00421-020-04355-z.

Nascimento, C.M., Ingles, M., Salvador-Pascual, A., Cominetti, M.R., Gomez-Cabrera, M.C., Viña, J. (2019). Sarcopenia, frailty and their prevention by exercise. *Free Radical Biology and Medicine*, *132*, 42–49. DOI: 10.1016/j.freeradbiomed.2018.08.035.

Nicklas, B.J., Chmelo, E., Delbono, O., Carr, J.J., Lyles, M.F., Marsh, A.P. (2015). Effects of resistance training with and without caloric restriction on physical function and mobility in overweight and obese older adults: A randomized controlled trial. *American Journal of Clinical Nutrition*, *101* (5), 991–999. DOI: 10.3945/ajcn.114.105270.

Paoli, A., Pacelli, Q. F., Moro, T., Marcolin, G., Neri, M., Battaglia, G., Sergi, G., Bolzetta, F., Bianco, A. (2013). Effects of high-intensity circuit training, low-intensity circuit training and endurance training on blood pressure and lipoproteins in middle-aged overweight men. *Lipids in Health and Disease*, *12* (1), 1–8. DOI: 10.1186/1476-511X-12-131.

Park, M.J., Cho, J.H., Chang, Y., Moon, J.Y., Park, S., Park, T.S., Lee, Y.S. (2020). Factors for predicting noninvasive ventilation failure in elderly patients with respiratory failure *Journal of Clinical Medicine*, *9* (7), 2116. DOI: 10.3390/jcm9072116.

Ramirez-Campillo, R., Alvarez, C., Garcìa-Hermoso, A., Celis-Morales, C., Ramirez-Velez, R., Gentil, P., Izquierdo, M. (2018). High-speed resistance training in elderly women: Effects of cluster training sets on functional performance and quality of life. *Experimental Gerontology*, *110*, 216–222. DOI: 10.1016/j.exger.2018.06.014.

Rubenstein, L.Z. (2006). Falls in older people: Epidemiology, risk factors and strategies for prevention. *Age and Ageing*, *35* (SUPPL.2). DOI: 10.1093/ageing/afl084.

Sahin, U.K., Kirdi, N., Bozoglu, E., Meric, A., Buyukturan, G., Ozturk, A., Doruk, H. (2018). Effect of low-intensity versus high-intensity resistance training on the functioning of the institutionalized frail elderly. *International Journal of Rehabilitation Research*, *41* (3), 211–217. DOI: 10.1097/MRR.0000000000000285.

Shiotsu, Y., Yanagita, M. (2018). Comparisons of low-intensity versus moderate-intensity combined aerobic and resistance training on body composition, muscle strength, and functional performance in older women. *Menopause*, *25* (6), 668–675. DOI: 10.1097/GME.0000000000001060.

Sparrow, D., Gottlieb, D.J., Demolles, D., Fielding, R.A. (2011). Increases in muscle strength and balance using a resistance training program administered via a telecommunications system in older adults. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*, *66 A* (11), 1251–1257. DOI: 10.1093/gerona/glr138.

Sylliaas, H., Brovold, T., Wyller, T.B., Bergland, A. (2011). Progressive strength training in older patients after hip fracture: A randomised controlled trial. *Age and Ageing*, *40* (2), 221–227. DOI: 10.1093/ageing/afq167.

Takahashi, T., Ishida, K., Yamamoto, H., Takata, J., Nishinaga, M., Doi, Y., Yamamoto, H. (2006). Modification of the functional reach test: analysis of lateral and anterior functional reach in community-dwelling older people. *Archives of gerontology and geriatrics*, *42* (2), 167–173. DOI: 10.1016/j.archger.2005.06.010.

Tournadre, A., Vial, G., Capel, F., Soubrier, M., Spine, Y.B. (2019). Sarcopenia. *Elsevier*, *2019* (86), 309–314. DOI: 10.1016/j.jbspin.2018.08.001.

Van Breukelen, G J.P. (2006). ANCOVA versus change from baseline had more power in randomized studies and more bias in nonrandomized studies. *Journal of Clinical Epidemiology*, *59* (9), 920–925. DOI: 10.1016/j.jclinepi.2006.02.007.

Vickers, A.J., Altman, D.G. (2001). Statistics Notes: Analysing controlled trials with baseline and follow up measurements. *British Medical Journal*, *323* (7321), 1123–1124 DOI: 10.1136/bmj.323.7321.1123.

Watson, S.L., Weeks, B.K., Weis, L.J., Horan, S.A., Beck, B.R. (2015). Heavy resistance training is safe and improves bone, function, and stature in postmenopausal women with low to very low bone mass: novel early findings from the LIFTMOR trial. *Osteoporosis International*, *26* (12), 2889–2894. DOI: 10.1007/s00198-0153263-2.

World Health Organization (WHO). (2010). Global recommendations on physical activity for health. *Geneva World Heal Organ*, *60*. Retrieved from: https://www.who.int/dietphysicalactivity/physicalactivityrecommendations65years.pdf.

World Health Organization (WHO). (2019). WHO. https://www.who.int/gho/ncd/en/.

Wu, H., Ouyang, P. (2017). Fall prevalence, time trend and its related risk factors among elderly people in China. *Archives of Gerontology and Geriatrics*, *73*, 294–299. DOI: 10.1016/j.archger.2017.08.009.

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ANTHROPOMETRIC CHARACTERISTICS OF VOLLEYBALL PLAYERS WITH RESPECT TO PLAYING POSITIONS: IN ETHIOPIAN FEMALE PREMIER LEAGUE

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Abstract The aim of this study was to investigate the anthropometric characteristics of Ethiopian female premier league volleyball players in relation to playing positions. The study encompassed 42 female premier league volleyball players (age: 25.60 ± 6.4 years). The players were categorized on the bases of playing position: including: -setters (n = 5), middle blockers (n = 7), outside-hitters (n = 11), opposite hitters (n = 11), and liberos (n = 8). Anthropometric measurements such as: five basic, six body lengths, six body circumferences, and five skinfolds were assessed. Descriptive statistics and One-Way ANOVA were used to identify the differences among the anthropometric characteristics of the players' at different playing positions. Significant mean differences were separated using the Tukey $B^{a,b}$ mean difference test at $P < 0.05$.The result revealed that there were significant differences in standing height, sitting height, standing reach height, arm and leg lengths among female volleyball players in different playing positions. However, the differences in weight, BMI, body circumferences, and skinfolds were not significant. Up on the results, it was possible to conclude that players' anthropometry is among the factors that affect success in a game. Considering players' anthropometry seems to be crucial at the time of selection and assigning of players to playing positions.

Keywords anthropometric characteristics, playing positions, premier league, volleyball

Introduction

In team sports, the specificities of each player's position must be considered along with their anthropometric characteristics. In volleyball, middle hitters, passer hitters, opposites, setters, and liberos differ in their roles and require different skills and tactics during matches (Grgantov Padulo, Milić, Ardigò, Erceg, Cular, 2017). Previous studies showed the necessity of players with appropriate anthropometric characteristics, which heavily influence the player's position in the team (Katic et al., 2007; cited in Goran, Majstorovıc, Osmankac, Mılenkoskı, Uslu, 2014).

Tian, (2006), cited in Zhang, (2010), found that the height advantage over the volleyball net always means mastery of the game. He further reported that height is decided by a combination of the athlete's body height and the jumping height, and usually it is shown in blocking height and spiking height. He also explained that if a team does not have net dominance, it will lose its ability to score. Gualdi-Russo and Zaccagni (2001) cited in Zhang (2010) also found that the volleyball players had significantly different anthropometric characteristics according to their game roles. They indicated that the setters were the lightest, the shortest, and the fattest; the spikers were the heaviest; and the second spikers were the tallest.

Trajković, Milanović, Sporiš, Radisavljević, (2011) also found that significant differences exist among youth volleyball players in different playing positions in body height, body weight, and standing reach height. Their finding was supported by Ling (2007), who mentioned that volleyball players at different positions had different anthropometric characteristics, especially in height. Ling (2007) reported the height of prominent volleyball players in the world. The average height of setters was 180–185 cm, of the spikers' 185–190 cm, of the second spikers' 190-200 cm, and of the second setters it was 185–195 cm.

In Ethiopia, though a few researches were conducted in the area of volleyball players, no scientific evidence was generated on female premier league volleyball players regarding their anthropometric characteristics related to their playing positions and hence their current status is not well known. Therefore, the purpose of this study was to investigate the anthropometric characteristics of Ethiopian female premier league volleyball players in relation to playing positions.

Methods

Study Design

The study was conducted using a cross-sectional research design to investigate the anthropometric characteristics of Ethiopian female volleyball premier league players in relation to their playing position.

Subjects

The participants of the study were female volleyball players from Ethiopian premier league clubs, namely Wolaita Sodo University, Maremia Betoch (Federal Prison), Geta Zeru, and National Alcohol Industry clubs. These premier league clubs were actively participating in the 2020/21 Ethiopian Premier League competition year.

Therefore, 42 female volleyball players, with an average age of 25.60 (±6.4) years old, and with 2.40 (±2.91) years of project level training experience, 7.62 (±6.4) years of club level playing experience, 3-6 training days per week, participated.

Procedures

All participants were informed about the objective and methodology of the study, and they voluntarily participated by signing a written informed consent form. Measurements were taken in the month of February 2021, when players were in between the end of preseason and the beginning of the season.

Personal profiles of players like age, project experience, club level playing experience, by week training dates and playing positions were documented by asking the players and cross-checked with the clubs' roster. For each of the variables, the instruments were adopted from different sources.

To achieve the intended outcome of the research, anthropometric measurements were collected from players through practical tests. Height, weight, body length, and circumferences were measured using a tape meter and weighing machine; BMI was calculated by the formula: Body Mass Index = Weight/Height; Skin folds were measured using caliper. Players' positions were: setters (n = 5), middle blockers (n = 7), outside hitters (n = 11), opposite hitters (n = 11), and liberos (n = 8).

All measurements were conducted by skilled, trained, and experienced sport science professionals and volleyball coaches.

Statistical Analysis

The Statistical Package for Social Sciences software (SPSS, version 26) was used to analyze the data. Descriptive statistics and One-Way ANOVA were used to identify the differences among the anthropometric characteristics of the players at different playing positions. Significant mean differences were separated using *Tukey B* [a,b] at 5% ($p < 0.05$) significance level.

Results

The findings pertaining to the anthropometric characteristics per playing position of female volleyball players are presented in Table 1.

Table 1. Anthropometric measurements by playing position (Mean + SD)

AVs	MB (n = 7)	OpH (n = 11)	OtH (n = 11)	S (n = 5)	L (n = 8)
1	2	3	4	5	6
Standing Height (cm)	174.43 ±4.89	173.91 ±5.22	176.36 ±4.01	166.80 ±6.26	164.00 ±5.98
Sitting Height (cm)	83.57 ±5.77	83.00 ±4.84	84.55 ±3.67	77.40 ±3.91	77.50 ±5.73
Standing Reach Height (cm)	230.00 ±6.22	229.91 ±13.69	232.27 ±5.53	216.00 ±4.9	214.00 ±6.41
Weight (kg)	68.00 ±6.38	63.82 ±12.18	65.73 ±5.97	66.60 ±11.44	61.37 ±10.89
BMI kg/m2	22.36 ±1.87	21.02 ±3.35	21.12 ±1.78	23.86 ±3.02	22.66 ±2.77
Arm Length (cm)	58.86 ±3.13	57.82 ±2.75	59.18 ±2.96	55.00 ±2.55	54.00 ±3.16
Forearm Length(cm)	28.43 ±1.62	28.09 ±1.87	28.64 ±2.29	26.20 ±0.84	27.38 ±1.41
Upper Arm Length (cm)	36.00 ±2.38	35.00 ±1.84	35.73 ±2.28	32.80 ±2.78	33.25 ±1.67
Leg Length(cm)	92.00 ±3 .46	91.82 ±4.09	94.82 ±3.28	85.40 ±3.65	85.00 ±5.13

1	2	3	4	5	6
Upper Leg Length (cm)	52.00 ±3.96	49.36 ±3.26	51.82 ±2.56	48.00 ±2.45	48.25 ±3.06
Lower Leg Length (cm)	47.00 ±1.53	47.09 ±1.92	48.55 ±1.64	43.60 ±2.07	43.13 ±2.10
Upper Arm Circumference (cm)	28.29 ±2.69	27.18 ±3.03	26.82 ±2.18	27.70 ±1.72	27.75 ±3.66
Forearm Circumference (cm)	24.00 ±1.83	23.45 ±1.44	23.45 ±1.64	23.20 ±1.48	24.00 ±1.93
Chest Circumference (cm)	89.57 ±4.39	87.18 ±6.68	86.55 ±1.64	91.40 ±7.99	86.88 ±6.58
Waist Circumference (cm)	84.14 ±9.51	76.55 ±7.44	77.55 ±5.61	83.40 ±11.97	78.13 ±8.20
Hip Circumference (cm)	99.00 ±6.83	97.91 ±8.29	97.73 ±5.42	98.80 ±10.83	95.63 ±6.61
Calf Circumference (cm)	35.43 ±3.36	34.91 ±2.63	35.73 ±1.74	35.60 ±2.70	35.25 ±4.30
Triceps (mm)	22.57 ±7.09	20.45 ±6.31	20.09 ±4.23	21.00 ±2.24	21.00 ±5.93
Biceps (mm)	18.57 ±6.08	17.27 ±7.5	17.73 ±5.48	21.20 ±3.9	16.88 ±6.73
Sub Scapular(mm)	18.00 ±5.80	18.82 ±6.49	14.64 ±4.78	21.00 ±6.25	16.50 ±3.51
Supra Spinal(mm)	21.29 ±10.24	16.91 ±6.17	15.64 ±5.37	22.20 ±10	19.00 ±7.62
Medial calf	18.43 ±4.20	20.36 ±5.16	20.55 ±4.78	20.80 ±2.39	21.75 ±6.88
Sum skinfold	98.86 ±24.44	93.82 ±26.39	88.64 ±17.81	106.20 ±20.13	95.13 ±25.27

AVs = anthropometric variables, MB = middle blockers, OpH = opposite hitters, OtH = outside hitters, S = setters, L = liberos, sum skin folds = the sum of triceps, biceps, sub scapular, supra spinal and medial calf.

The statistical analysis showed that there were differences in standing height among the playing positions (Table 1). The highest mean standing height was obtained from the outside hitters (OtH) followed by middle blockers (MB) and opposite hitters (OpH), while the lowest was obtained from liberos (L) and setters (S) (Table 1). Similarly, there were differences in sitting height among the playing positions (Table 1). A relatively higher sitting height was recorded for OtH followed by MB and OpH while the lowest was recorded for S and L.

Alike the above, the statistics of standing reach indices differentiate female volleyball players of one playing position from the others. The highest mean standing reach was recorded for OtH followed by MB and OpH, whereas the lowest was recorded for S and L (Table 1). Body weight and BMI were taken as two comparative variables for players at different playing positions .A relatively higher body weight was recorded for MB followed by S, OtH, OpH, and L. The result revealed that MB had a relatively higher body weight while L had a relatively lower body weight. On the other hand, a relatively higher BMI was recorded for S followed by L, MB, OtH and OpH (Table 1).

As presented in Table 1, OtH players had relatively higher mean arm length, forearm length, leg length, and lower leg length than other players, while MB players had relatively higher mean upper arm length and lower leg length than other players. On the contrary, S and L had relatively lower arm and leg lengths. But, OpH players had medium body length.

There was a slight difference in body circumference among female volleyball players by their positional category. MB position players had relatively higher mean upper arm, forearm, waist, and hip circumferences compared to other positions. Whereas, OtH players had relatively higher mean calf circumference but lower mean upper arms, chests, waists, and hips. On the other hand, OpH players had comparatively lower mean upper arm, waist, and calf circumferences and moderate forearm, chest, and hip circumferences compared with other position players. While L players had relatively higher mean upper arm, forearm, moderate waist, and small chest, hip, and calf circumference (Table 1). S players had relatively large mean chest, waist, hip, and calf circumferences, moderate upper arm, and low forearm circumferences.

The statistical analysis on skinfold measurement (Table 1) indicated that S had relatively larger biceps, subscapular, supraspinal and sum skinfolds while MB had relatively higher triceps, moderate biceps, subscapular, supraspinal, and sum skinfolds, and a low medial calf average score. In addition, OpH and OtH had relatively similar mean skinfold measurements except subscapular (OpH moderate and OtH low). They had relatively low mean values in triceps, supraspinal and sum skinfold and moderate mean values in biceps and medial calf (Table 1).

Table 2. Base measurements by playing position (Mean difference)

PPs	StH	SiH	SrH	W	BMI
MB	174.43a	83.57ab	230.00a	68.00a	22.36a
OpH	173.91a	83.00ab	229.91a	63.82a	21.02a
OtH	176.36a	84.55a	232.27a	65.73a	21.12a
S	166.80b	77.40b	216.00b	66.60a	23.86a
L	164.00b	77.50b	214.00b	61.38a	22.66a
p	***	**	***	NS	NS

** = significant at $p < 0.01$; *** = significant at $p < 0.000$, NS = none significant $p > 0.05$; PPs = playing positions of players, StH = standing height, SiH= sitting height, SrH = standing reach height, W = weight, MB = middle blockers, OpH = opposite hitters, OtH = outside hitters, S = setters, L = liberos.

Analysis of variance showed highly significant differences in StH, SiH and SrH among the playing positions but no significant difference in W and BMI (Table 2). Hence, the highest StH and SiH were obtained from OtH followed by MB and OpH while the lowest was from L for StH and S for SiH (Table 2). However, the mean StH, SiH and SrH were at par for OtH, MB and OpH. In addition, there was no significant difference between S and L in StH, SiH, and SrH (Table 2).

Table 3. Length measurements by playing position (Mean difference)

PPs	AL	FAL	UAL	LL	ULL	LLL
MB	58.86ab	28.43a	36.00a	92.00a	52.00a	47.00a
OpH	57.82abc	28.09a	35.00ab	91.82a	49.36a	47.09a
OtH	59.18a	28.64a	35.73ab	94.82a	51.82a	48.55a
S	55.00bc	26.20a	32.80b	85.40b	48.00a	43.60b
L	54.00c	27.38a	33.25ab	85.00b	48.25a	43.13b
p	***	NS	**	***	NS	***

** = significant at p < 0.01; *** = significant at p < 0.00;, NS = none significant p > 0.05; PPs = playing positions of players, AL= arm length, FAL= forearm length, UAL= upper arm length, LL = leg length, ULL = upper leg length, LLL= lower leg length, MB = middle blockers, OpH = opposite hitters, OtH = outside hitters, S = setters, L= liberos.

Analysis of variance showed highly significant differences in AL, FAL, UAL, LL and LLL for players in different playing positions while no significant difference was observed in ULL (Table 3). The highest AL, FAL, LL and LLL were measured for OtH followed by MB whereas the lowest AL, FAL, UAL, LL and LLL was measured for L playing position (Table 3). However, the difference in length measurements was at par for MB, OpH and OtH playing positions. The highest UAL was measured from between MB followed by OtH and OpH while the lowest was measured for S playing position.

Table 4. Circumference measurements in different playing positions (Analysis of variance)

PPs	UAC	FAC	ChC	WC	HC	CC
MB	28.29a	24.00a	89.57a	84.14a	99.00a	35.43a
OpH	27.18a	23.45a	87.18a	76.55a	97.91a	34.91a
OtH	26.82a	23.45a	86.55a	77.55a	97.73a	35.73a
S	27.70a	23.20a	91.40a	83.40a	98.80a	35.60a
L	27.75a	24.00a	86.88a	78.13a	95.63a	35.25a
p	NS	NS	NS	NS	NS	NS

NS = None significant difference p > 0.05; PPs = playing positions of players; UAC = upper arm circumference; FAC = forearm circumference; ChC = chest circumference; WC = waist circumference; HC = hip circumference; CC = calf circumference; MB = middle blockers; OpH = opposite hitters; OtH = outside hitters; S = setters, L = liberos.

No significant difference was observed in circumference and skin fold measurements between players in different playing positions (Table 4 and 5).

Table 5. Skin fold measurements in different playing positions (Analysis of variance)

PPs	Tr	Bi	Sub	Sup	Me	∑5SF
MB	22.57a	18.57a	18.00a	21.29a	18.43a	98.86a
OpH	20.45a	17.27a	18.82a	16.91a	20.36a	93.82a
OtH	20.09a	17.73a	14.64a	15.64a	20.55a	88.64a
S	21.00a	21.20a	21.00a	22.20a	20.80a	106.20a
L	21.00a	16.88a	16.50a	19.00a	21.75a	95.13a
p	NS	NS	NS	NS	NS	NS

NS = None significant difference p > 0.05; PPs = playing positions of players, Tr = triceps, Bi = biceps, Sub = sub scapular, Sup = supra spinal, Me = medial calf, ∑5SF = sum of s skin folds, MB = middle blockers, OpH = opposite hitters, OtH = outside hitters, S = setters, L = liberos.

Discussion

Female volleyball players' anthropometric characteristics are influenced by role specialization. Considering the specialized and different roles of each position, it is likely that differences exist and are desired in anthropometric profiles among the playing positions to optimize performance (Mielgo-Ayuso, Calleja-González, Clemente-Suárez, Zourdos, 2015) and provide important prerequisites for outstanding performance (Stamm Veldre, Stamm, Thomson, Kaarma, Loko, Koskel, 2003). Thus, this study aimed to investigate the anthropometric characteristics of female premier league volleyball players in relation to playing positions. The information obtained provides a general picture of the players' characteristics in relation to their position.

Female volleyball players in various playing positions differed significantly in standing height, sitting height, and standing reach height, whereas no significant differences were found in body mass and body mass index between players in different positions. Middle blockers, outside-hitters, and opposites are taller and have higher standing reaches than setters and liberos. These results confirm previous investigations in relation to female volleyball players' position (Gualdi-Russo Zaccagni, 2001; Malousaris Bergeles, Barzouka, Bayios, Nassis, Koskolou, 2008; Zhang, 2010; Carvajal et al., 2012; Martin-Matillas et al., 2014; Palao, Manzanares, Valadés, 2014; Milić et al., 2017).

As stated by Vujmilović and Karalić (2014), from the point of modern volleyball, very tall females have an objectively greater prospective for successful engagement in volleyball, which every year becomes more of a "privilege" for tall male and female players. But Ethiopian volleyball players are lower than Italian, Greek, Chinese, Cuban, and Spanish female volleyball team players (Palao, Manzanares, Valadés, 2014), Spanish Super-League female volleyball players (Mielgo-Ayuso et al., 2015), and African, American, Asian, Chinese, and European female volleyball players (Zhang, 2010) by their height and weight of all playing position players.

Concerning body length measurements, in the current investigation, significant differences were observed between volleyball players by their positional differences. Thus, setters and liberos showed relatively lower arm and leg lengths, while middle blockers, outside hitters, and opposite hitters showed relatively higher arm and leg lengths. This is related to that of height measurements.

With regard to body circumferences, no significant difference was observed among Ethiopian volleyball players by their playing position. These results contradict those of Mielgo-Ayuso et al. (2015). In this study, players at all positions showed relatively higher body circumferences than Spanish Super-League female volleyball players (Mielgo-Ayuso et al., 2015).

In the current study, no significant differences were observed among volleyball players by their playing positions in five skinfold measurements. Like body circumference measurement results; this also contrasts with the results of the findings of Zhang (2010) and Mielgo-Ayuso et al. (2015). Their finding indicates significant differences between volleyball players in skinfold measurement.

Conclusion

Appropriate anthropometric characteristics are one criterion to determine the playing position of players at the time of the game. Regarding this, Katic et al., (2007), mentioned that volleyball players required enhancing their motor, technical, and tactical abilities and skills in individual, group, and collective aspects. Besides that, it requires players with appropriate anthropometric characteristics, which largely determine the position of the player on the team. In the current research, significant differences were observed in standing height, sitting height, standing reach height, and arm and leg lengths among female volleyball players in different playing positions. But, significant differences were not shown by weight, BMI, body circumferences, and skinfold measurement between players in different playing positions.

Although Ethiopian female volleyball players in five playing positions are lower than other world female volleyball players by their anthropometric characteristic measurements, this may be considered one factor which affects their success in a game. Considering players' anthropometry seems to be crucial at the time of selection and assigning of players to playing positions.

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References

Carvajal, W., Betancourt, H., León, S., Deturnel, Y., Martínez, M., Echevarría, I., Castillo, M.E., Serviat, N. (2012). Kinanthropometric Profile of Cuban women Olympic volleyball champions. *MEDICC Review*, *14* (2), 16–22.

Goran, N., Majstorovıc, N., Osmankac, N., Mılenkoskı, J., Uslu, S. (2014). Differences in Anthropometric Characteristics and Motor Abilities between Volleyball Players and Untrained Boys 17 Years Old. *International Journal of Science Culture and Sport*, *2* (8), 103–103. https://doi.org/10.14486/ijscs215.

Grgantov, Z., Padulo, J., Milić, M., Ardigò, L.P., Erceg, M., Cular, D. (2017). Intra-Positional and Inter-Positional Differences in Somatotype Components and Proportions of Particular Somatotype Categories in Youth Volleyball Players. *Annals of Applied Sport Science*, *5* (2), 37–49.

Gualdi-Russo, E., Zaccagni, L. (2001). Somatotype, role and performance in elite volleyball players. *J Sports Med PhysFitness*, *41* (2), 256–262.

Ling, G.Z. (2007). Physique and Event Specific Physical Capacities of Young Female Volleyball Players in China. *Journal of Physical Education*, *14*, 113–116.

Malousaris, G.G., Bergeles, N.K., Barzouka, K.G., Bayios, I.A., Nassis, G.P., Koskolou, M.D. (2008). Somatotype, size and body composition of competitive female volleyball players. *J Sci Med Sport*, *11* (3), 337–344.

Martín-Matillas, M., Valadés, D., Hernández-Hernández, E., Olea-Serrano, F., Sjöström, M., Delgado-Fernandez, M., Ortega, F.B. (2014). Anthropometric, body composition and somatotype characteristics of elite female volleyball players from the highest Spanish league. *Journal of Sports Sciences*, *32* (2),137–148. DOI: 10.1080/02640414.2013.809472.

Mielgo-Ayuso, J., Calleja-González, J., Clemente-Suárez, V.J., Zourdos, M.C. (2015).Influence of Anthropometric Profile on Physical Performance in Elite Female Volley Ballers in Relation to Playing Position. *Journal of Nutrición Hospitalaria*, *31* (2), 849–857.

Milić, M., Grgantov, Z., Chamari, K., Ardigò, L.P., Bianco, A., Padulo, J. (2017). Anthropometric and Physical Characteristics Allow Differentiation of Young Female Volleyball Players According to Playing Position and Level of Expertise. *Biol Sport*, *34* (1), 19–26.

Palao, J.M., Manzanares, P., Valadés, D. (2014). Anthropometric, physical, and age differences by the player position and the performance level in volleyball. *Journal of Human Kinetics*, *44* (1), 223–236. DOI: 10.2478/hukin-2014-0128.

Stamm, R., Veldre, G., Stamm, M., Thomson, M., Kaarma, H., Loko, J., Koskel, S. (2003). Dependence of young female volleyballers' performance on their body build, physical abilities, and psychophysiological properties. *J Sports Med & Physical Fitness*, *43* (3), 291–299.

Trajković, N., Milanović, Z., Sporiš, G., Radisavljević, M. (2011). Positional Differences in Body Composition and Jumping Performance Among Youth Elite Volleyball Players. *International Scientific Journal of Kinesiology*, *5* (1), 62–66.

Vujmilović, A., Karalić, T. (2014). Differences of Body Dimensions in Female Volleyball Players (cadets) in relation to volleyball playing position. *The Sport Journal*, 22.

Zhang Y. (2010). An investigation on the anthropometry profile and its relationship with physical performance of elite Chinese women volleyball players. MSc thesis, Southern Cross University, Lismore, NSW.ePublications@SCU. Available at: http://epubs.scu.edu.au/theses/182/.

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ANTHROPOMETRIC VARIABLES AND PEFR

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Abstract Peak expiratory flow rate (PEFR) varies with anthropometric variables like calendar age, body height, body weight, and body surface area in different regions. The present study aims at analyzing the relationship of PEFR with anthropometric variables to know a reference value in this region. We conducted the present study on healthy adult males aged eighteen to forty-five years engaged in works where they were un-exposed to pollutants in Patiala, India. Subgroups were made in each anthropometric variable category. PEFR recording was done using Mini Wright Peak Flow Meter. Results are expressed as mean PEFR ± standard deviation (mean ±S.D.), while the students' t-test was used to determine the differences between the means. We observed a linear increase in PEFR with all anthropometric variables. The correlation of PEFR with anthropometric variables was determined. PEFR is positively correlated with body height and body surface area ($r = +0.20$) and negatively correlated with calendar age ($r = -0.24$) and body weight ($r = -0.02$). We conclude that PEFR correlates best with body height ($r = +0.48$), and the result is highly significant ($p < 0.01$).

Keywords anthropometric variables, body surface area, peak expiratory flow rate (PEFR), peak flow meter, smoking

Introduction

Variation in lung functions can be seen in India as there is a variation in geographical, climatic, anthropometric, nutritional, and socioeconomic conditions (Raju, Prasad, Ramana, Murthy, 2004). Peak expiratory flow rate (PEFR) is affected by calendar age, body weight, body height and body surface area (anthropometric variables) which varies in different regions (Godfrey, Kamburoff, Nairn,1970). It is important to have a normal reference value for each region. The present paper will show the normal value of PEFR and the effect of various anthropometric variables on

PEFR of healthy adult males in the age group of eighteen to forty-five years engaged in works where they are not exposed to pollutants in the city of Patiala.

Material and Methods

Participants: Two hundred healthy, non-smoking adult males aged eighteen to forty-five years in the city of Patiala who are engaged in works where exposure to pollutants is not present were selected randomly. The institutional ethical committee approved the study. Smoking is a significant cause of respiratory symptoms and reduction in ventilatory capacity (Medabala, Rao, Mohesh, Kumar, 2013), so it is essential to take non-smokers. We excluded participants who were smokers, with a history of cardiovascular problems, wheezing and respiratory diseases, or taking any drug affecting the respiratory system from the study. Subgroups were made according to the subjects' calendar age, body height, body weight, and body surface area (BSA).

Calendar age was calculated in years to the nearest 0.5 years (yrs.). Body height was measured by making the subject stand bare-footed on the floor against the wall, with slightly separated heels and buttocks back in contact with the wall, and measured to the nearest centimeter (cm). Body weight was measured in kilograms (kgs) with the subject standing on a portable weighing machine without wearing shoes. Body surface area was calculated in square meters using Dubois formula (Dubois, Dubois, 1916) B.S.A (m^2) = 0.007184 x W0.425 x H 0.725 where W is weight in kgs and H is height in cms.

According to calendar age, they were divided into three groups, i.e., Group I: 18–27 years, Group II: 28–37 years, and Group III: ≥ 38 years. According to body height, subjects were divided into three groups, i.e., Group I: 148–157 cms, Group II: 158–167 cms, and Group III: 168–177 cms. As per body weight, they were divided into four groups, i.e., Group I: 35–44 kgs, Group II: 45–54 kgs, Group III: 55–64 kgs, and Group IV: ≥ 65 kgs. According to body surface area, they were divided into four groups, i.e., Group I: 1.2–1.40m^2, Group II: 1.41m^2–1.60m^2, Group III: 1.61m^2 –1.80m^2, and Group IV: ≥1.81m^2.

Measures: Immediately before the test, subjects completed a brief questionnaire to ensure that the subjects satisfied the criteria of healthy subjects. Informed written consent was taken from all the subjects.

Procedure: The principal investigator tested the subjects at their workplace. For PEFR, a Mini Wright Peak Flow meter (Clement Clarke International, United Kingdom) was used. Mini wright peak flow meter is very convenient to carry and use. PEFR is a simple test that makes it particularly suitable for respiratory function studies.

The test was done in the standing position. The subject was instructed to take maximal inspiration and blow into the instrument rapidly and forcefully. Three test repetitions were made, and the highest of these readings in liters/minute was taken for analysis.

Analysis: All the data were statistically analyzed. Results were expressed as mean PEFR ± standard deviation (mean ± S.D.), while the student's t-test was used to determine the differences between the means. P-values less than or equal to 0.05 ($P \leq 0.05$) were taken as statistically significant, and a P value of ≤0.001 were considered statistically highly significant.

Results

Table 1 shows the PEFR in study subjects according to three age groups. It shows that PEFR increases with calendar age till the age group of 28 years to 37 years, then declines. When the PEFR of study subjects was recorded according to four height groups, PEFR increased with the increase in body height, as shown in Table 2.

Table 3 shows the PEFR of study subjects according to four weight groups, and it shows that PEFR increases with the increase in body weight to 64 kgs and then, it declines slightly. Table 4 shows the PEFR in study subjects according to four body surface area groups; PEFR increases with the increase in body surface area. Table 5 shows the correlation of PEFR with calendar age, body weight, body height, and body surface area. The PEFR correlates best with body height.

Table 1. Mean and SD of PEFR in study subjects according to age groups

Group no.	Age (in years)	No. of subjects	Mean± SD of PEFR (Lts. /min.)
I	18–27	85	629.87 ±52.35
II	28–37	62	639.69 ±51.13
III	≥ 38	53	587.26 ±59.37

Table 2. Mean and SD of PEFR in study subjects according to height groups

Group no.	Height (cms)	No. of subjects	Mean± SD of PEFR (Lts. /min.)
I	148–157	13	584.69 ±30.83
II	158–167	89	600.71 ±63.34
III	168–177	98	645.51 ±43.62

Table 3. Mean and SD of PEFR in study subjects according to weight groups

Group no.	Weight (kg)	No. of subjects	Mean± SD of PEFR (Lts./min.)
I	35–44	–	–
II	45–54	19	597.42 ±58.76
III	55–64	87	626.79 ±55.97
IV	≥65	94	621.73 ±58.34

Table 4. Mean and SD of PEFR in study subjects according to body surface area groups

Group no.	BSA gps (m^2)	No. of subjects	Mean ± SD of PEFR (Lts. /min.)
I	1.21–1.40	–	–
II	1.41–1.60	35	587.62 ±52.93
III	1.61–1.80	128	634.28 ±50.91
IV	≥1.81	37	610.0 ±68.96

Table 5. Correlation of PEFR with age, weight, height and body surface area

Parameter	Coefficient of correlation	‘p’ value
PEFR	–	–
Age (in years)	–0.24	<0.01
Weight (in kgs.)	–0.02	>0.05
Height (in cms.)	+0.48	<0.01
BSA (in m^2)	+0.20	<0.01

* >0.05 is not significant, <0.01 is highly significant

Discussion

Peak Expiratory Flow Rate is an effort-dependent parameter, which measures the airflow emerging from the large airways within about 100-120 milliseconds (msec) of the start of forced expiration (Enright Linn, Edward, 2000). It remains at its peak for 10 msec (Jain, Kumar, Sharma, 1983). According to Wright and Mckerrow (1959), PEFR is the maximum expiratory flow rate sustained by a subject for at least ten milliseconds expressed in liters/minute (Wright-Mckerrow, 1959). Pulmonary function tests indicate the health status of individuals in a region (Schünemann, Dorn, Grant, Winkelstein, Trevisan,2000; Prakash, Meshram, Ramtekkar, 2007). There are various factors affecting PEFR: i) age, ii) height, iii) maximum expiratory pressure, which is a representation of respiratory muscle strength (Black, Hyatt, 1969; Smyth, Chapman, Rebuck, 1984), iv) volume and elastic properties of lungs which is a function of thoracic dimension and hence of stature, v) Volume history of the lung, that is, how the lung was stretched prior to the PEFR maneuver (Kano, Burton, Lateri, Sly, 1993; D'Angelo, Prandi, Marazzini, Milic, 1994). In the current study, PEFR was best correlated to body height even though it may correlate with other factors like calendar age, body weight, and body surface area, as in other studies (Gupta, Mishra, Mehta, Prasad, 1993; Dharamshi et al., 2015).

The present study reveals that mean PEFR in study subjects increased with the increase in calendar age till the age group of 28 years to 37 years, and then it starts declining. The correlation of coefficient is negative ($r = -0.24$), and these results are highly significant ($p < 0.01$), as shown in Table 5. Other studies report similar findings (Gregg, Nunn, 1973; Brooks, Waller, 1972; Malik, Jindal, Banga, Sharda, Gupta, 1980; Ogunlana, Oyewole, Lateef, Ayodeji,2021). PEFR is affected by the expiratory muscle's strength, the lungs' recoil pressure, and the airways' competency (Sahebjami, 1998). An increase in PEFR with age is due to an increase in muscular power with advancing age, and a decrease in PEFR after a certain age can be because this variable is dependent upon the effort of expiratory muscles, elastic recoil of lungs, and size of airways, factors which are known to reduce with advancing age. Jain et al. (1983) reported stiffness of the thoracic cage and loss of elastic recoil of lungs in older adults. So, the strength of the respiratory muscles decreases. They also report that loss of elastic recoiling prevents the closure of the respiratory bronchioles during expiration. Various factors are responsible for reducing ventilatory function in the elderly (Goyle, Venkatraman, Rastogi, Lakhera, Gautam, 1984). Regular aerobic exercise can achieve more significant cardio-respiratory benefits in older age groups for an extended time interval (Blumenthal et al., 1991).

There is a positive correlation of PEFR with body height ($r = +0.48$). The result is statistically significant ($p < 0.01$), as shown in Table 5, which shows an increase in PEFR with an increase in height. This observation is consistent with other studies (Cookson, Blake, Faranisi, 1976; Amin, Pande, 1978; Lockhart, Smith, Mair, Wilson, 1960; Ijaz, Bashir, Ikhlaq, Ijaz, Aftab, Zia, 2020; Ogunlana et al., 2021), and is probably due to more chest volume in the taller subjects. The growth of air passages and the effort of expiratory muscles also increase with an increase in height.

PEFR in study subject's increases with the increase in body weight till the weight group of 55–64 kgs, then declines. The same pattern is observed in other studies (Dharamshi et al., 2015; Ebomoyiy, Iyawe, 2005). However, the current study's relationship between body weight and PEFR is not statistically significant. The correlation of coefficient is negative ($r = -0.02$), and the results are not significant ($p > 0.05$), as shown in Table 5.

Body surface area is a function of both body height and body weight and therefore is a good outward expression of the nutritional standard of the individual (Vijay, Arun, Shivaprasad, Desai, 2014). PEFR positively correlates with body surface area (r = +0.20), and is statistically highly significant ($p < 0.01$) as shown in table 5, which shows an increase in the PEFR of study subjects with an increase in body surface area. This observation is consistent with other studies (Amin, Pande, 1978; Lockhart et al., 1960; Vijay et al., 2014).

Conclusion

We conclude that the PEFR of healthy individuals increases with calendar age and body weight till a particular age and weight, and then it declines. PEFR increases with an increase in body height and body surface area. PEFR is positively correlated with body height and surface area and negatively correlated with calendar age and body weight. The best correlation is between PEFR and body height.

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References

Amin, S.K., Pande, R.S. (1978). Peak expiratory flow rate in normal subjects. *The Indian Journal of Chest Diseases & Allied Sciences*, *20* (2), 81–83. PMID: 721164.

Black, L.F., Hyatt, R.E. (1969). Maximal respiratory pressures, normal values and relationship to age and sex. *American Review of Respiratory Disease*, 99, 696-702.

Blumenthal, J.A., Emery, C.F., Madden, D.J., Coleman, R.E., Riddle, M.W., Schniebolk, S., Cobb, F.R., Sullivan, M.J., Higginbotham, M.B. (1991). Effects of exercise training in cardiorespiratory function in men and women > 60 years of age. *American Journal of Cardiology*, *67* (7), 633-639. DOI: 10.1016/0002-9149(91)90904-y. PMID: 2000798.

Brooks, A.G.F., Waller, R.E. (1972). Peak flow measurements among visitors to a public health exhibition. *Thorax*, 27, 557–562.

Cookson, J.B., Blake, G.T.W., Faranisi, C. (1976). Normal values for ventilatory function in Rhodesian Africans. *British Journal of Diseases of the Chest*, *70* (2), 107–111.

D'Angelo, E., Prandi, E., Marazzini, L., Milic, E.J. (1994). Dependence of maximal flow volume curve on time course of preceding inspiration in patients with chronic obstructive pulmonary disease. *American Journal of Respiratory and Critical Care Medicine*, *150* (6), 1581–1586. DOI: 10.1164/ajrccm.150.6.7952618. PMID: 7952618.

Dharamshi, H.A., Faraz, A., Ashraf, E., Alam, S.S., Ali, A., Shakeel, O., Abidi, S.M.A., Rizvi, S.S., Fatima, Z., Wasy, H.A., Fatima, F., Mahar, M., Naqvi, T. (2015). Variation of PEFR with height, weight and waist-hip ratio in medical students. *International Archives of Medicine Section: Primary Care*, *8* (1). DOI: 10.3823/1683.

Dubois, D., Dubois, E.F. (1916). Clinical calorimetry: a formula to estimate the approximate surface area if height and weight be known. *The Archives of Internal Medicine*, *17* (6–2), 863–871. DOI: 10.1001/archinte.1916.00080130010002.

Ebomoyiy, M.Y., Iyawe, I. (2005). Variations of peak expiratory flow rate with anthropometric determinants in a population of healthy adult nigerians. *Nigerian Journal of Physiological Sciences*, *20* (12), 85–89.

Enright, P., Linn, W.S., Edward, L. (2000). Quality spirometry test performance in children and adolescents: Experience in a large field study. *Chest*, 118, 665–671.

Godfrey, S., Kamburoff, P.L., Nairn, J.R. (1970). Study of peak expiratory flow rates on a sample of 382 normal boys and girls using standard Wright peak flow meter. *British Medical Journal of Diseases of Chest*, *64*, 15.

Goyle, B.R., Venkatraman, C., Rastogi, S.K., Lakhera, S.C., Gautam, R.K. (1984). Normal standards and prediction of lung function tests in Indian Armed Forces personnel. *Medical Journal of Armed Forces India*, *40*, 151–156.

Gregg, I., Nunn, A.J. (1973). Peak expiratory flow rate in normal subjects. *British Medical Journal*, *3*, 282–284.

Gupta, C.K., Mishra, G., Mehta, S.C., Prasad, J. (1993). On the contribution of height to predict lung volumes, capacity diffusion in healthy school children of 10–17 yr. *Indian Journal of Chest Diseases and Allied Sciences*, *35*, 167–177.

Ijaz, A., Bashir, I., Ikhlaq, A., Ijaz, F., Aftab, R.K., Zia, R. (2020) Correlation Between Peak Expiratory Flow Rate, Markers of Adiposity, and Anthropometric Measures in Medical Students in Pakistan. *Cureus*, *12* (12): e12408. DOI:10.7759/cureus.12408.

Jain, S.K., Kumar, R., Sharma, D.A. (1983). Peak expiratory flow rates in healthy Indian adults: A statistical evaluation-I. *Lung India*, *3* (1), 88–91.

Kano, S., Burton, D.L., Lateri, C.J., Sly P.D. (1993). Determination of peak expiratory flow. *European Respiratory Journal*, *6* (9), 1347–1352. PMID: 8287953.

Lockhart, W., Smith, D.H., Mair, A., Wilson, W.A. (1960). Practical experience with peak flow meter. *British Medical Journal*, *1* (5165), 37–38. DOI: 10.1136/bmj.1.5165.37. PMID: 14417800; PMCID: PMC1966361.

Malik, S.K., Jindal, S.K., Banga, N., Sharda, P.K., Gupta, H.D. (1980). Peak expiratory flow rate of healthy north Indian teachers. *Indian Journal of Medical Research,* 71, 322–332.

Medabala, T., Rao, B.N., Mohesh, M.I.G., Kumar, M.P. (2013). Effect of cigarette and cigar smoking on peak expiratory flow rate. *Journal of Clinical and Diagnostic Research*, *7* (9), 1886–1889. DOI: 10.7860/JCDR/2013/6726.3342.PMID: 24179889, PMCID: PMC3809628.

Ogunlana, M.O., Oyewole, O.O., Lateef, A.I., Ayodeji, A.F. (2021). Anthropometric determinants of lung function in apparently healthy individuals. *South African Journal of Physiotherapy*, *77* (1), a1509. DOI: 10.4102/sajp.v77i1.1509.

Prakash, S., Meshram, S., Ramtekkar, U. (2007) Athelets, yogis and individual with sedentary life styles; do their lung function differ? *Indian Journal of Physiology and Pharmacology*, *51*, 76–80.

Raju, P.S., Prasad, K.V., Ramana,Y.V., Murthy, K.J. (2004). Pulmonary function tests in Indian girls- prediction equations. *Indian Journal of Paediatrics*, *71*, 893–897.

Sahebjami, H. (1998). Dyspnea in obese healthy men. *Chest*, *114*, 1373–1377.

Schünemann, H.J., Dorn, J., Grant, B.J., Winkelstein, W. Jr., Trevisan, M. (2000). Pulmonary function is the long-term predictor of mortality in the general population: 29 years' follow-up of the buffalo health study. *Chest*, *118*, 656–664.

Smyth, R.J., Chapman, K.R., Rebuck, A.S. (1984) Maximal inspiratory and expiratory pressures in adolescents, normal values. *Chest*, *4*, 569–572.

Vijay, K.K., Arun, K.S., Shivaprasad, V., Desai, R.D. (2014). Peak expiratory flow rate and its correlation with body surface area in healthy school children. *Journal of Scientific and Innovative Research*, 2014, *3* (4), 397–401.

Wright, B.M., Mckerrow, C.B. (1959). Maximum forced expiratory flow rate as a measure of ventilatory capacity with a description of a new portable instrument for measuring it. *British Medical Journal*, *21*, 1041–1046.

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THE EFFECT OF EXERCISE DEPENDENCE AND NARCISSISM COMPONENTS ON EATING DISORDERS IN MEN BODYBUILDERS

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Abstract Physical activity is considered a healthy behavior as lifestyle component that can prevent chronic disease and attributed to numerous psychological and physical benefits. The purpose of this study was to investigate the effect of exercise dependence and narcissism components on eating disorders in male bodybuilders.

The study was a correlational study and the statistical population consisted of male bodybuilders in city clubs with more than one year of continuous training of at least three sessions a week. 250 male bodybuilders were selected by cluster sampling. The research tool consisted of three questionnaires: narcissistic personality, exercise dependency and eating disorders. For data analysis correlation and regression tests were performed by SPSS version 21 and p-value less than 0.05 was considered as significant.

The results showed that addiction to exercise and narcissism and their components had a significant positive relationship with eating disorders (all P-values < 0.01). Regression models revealed that exercise dependence and narcissism were able to predict 46% of variance in eating disorder ($p < 0.01$).

According to the data, nutritional behaviors can be promoted by improving narcissistic tendencies and dependency on exercise.

Keywords bodybuilding, exercise dependence, eating disorders, narcissism

Introduction

The prevalence of eating disorders (EDs) and its consequences such as lack of self-confidence, depression and physical dissatisfaction has increased significantly over the past years (Stice, 2002). Different researches show that EDs are associated with a set of dysfunctional attitudes. Recently, it has been identified that exercise dependence play an important role in association between exercise and ED (Bratland Sanda, 2011). While the benefits of continued participation in physical activity are widely accepted, in some cases, physical activity can lead to adverse psychological outcomes. Exercise and physical activity have many physical and psychological benefits. However, excessive physical activity can have negative consequences and may be related to exercise. Exercise dependence is a tendency to intense physical activity that results in physiological (over-injury, endurance) and negative psychological symptoms (particularly when unable to exercise) (Lejoyeux, 2008).

Sachs (1981) defines dependence and addiction to exercise as a type of psychological and physiological dependence on regular exercise, with symptoms characterized by 24 to 36 hours of indeterminacy. Symptoms include anxiety, restlessness, sense of guilt, irritability, tension and discomfort, as well as apathy, laziness, loss of appetite, insomnia and headaches. The incidence of these symptoms is important in determining the presence and severity of exercise addiction (Sachs, 1981). Researches around the world confirm that athletes can depend on exercise for a variety of reasons (Sachs, 1981). Costa and Oliva (2012) reported that there was a significant relationship between exercise dependence and some personality traits, while extraversion, neuroticism, and adaptation could potentially be the underlying factors in determining the cause of exercise dependence. These results may be relevant for the possible diagnosis of individuals at risk for exercise-related behavior disorder (Costa, 2012). In the last few decades, young adults and adolescents paid increasing attention to improve the appearance of their body especially by growing muscle mass. This tendency in bodybuilders, who spend most of their time in fitness centers, have caused several mental related disorders (Costa, 2012).

Brosof, Williams and Levinson (2019) studied the exercise dependence contribution to ED symptoms and they found that withdrawal, tolerance, and time significantly affected ED symptoms. They reported that lack of control, withdrawal and time, positively predicted ED symptoms, when adjusting for baseline symptoms and negative affect (Brosof, 2019). Scharmer et al. (2019) suggested that compulsive qualities of exercise in order to control shape and weight are strongly associated with severity of ED pathology (Scharmer, 2019). Therefore, understanding the etiology of this relationship can be helpful in treatment of EDs and also identifying those who are most at risk.

Another important benefit of exercise is its potential in increasing self-esteem. A person’s scientific, social, emotional, and physical satisfaction is referred to as self-worth (Fox, 1997). Despite a variety of healthy outcomes, self-worth can be overwhelming, which usually manifests itself in a form of narcissism. Exercise and sport may be mediators of narcissistic goals that lead to increased focus on appearance (Davis, 1992). Narcissistic individuals have traits such as persistent narcissism, fantasizing about unlimited success, power or beauty, and the urge to be exhibitionist for being admired (SHafiee, 2011). People with EDs often exhibit symptoms of narcissistic traits (Yarock, 1993). Campbell and Waller (2010) in their study on narcissistic characteristics and ED behaviors in women, demonstrated that there was a significant positive relationship between over-exercise and narcissism and there was also a multidimensional relationship between eating disorder behaviors and specific aspects of narcissism (Campbell, 2010). The results of Sivanathan et al. (2019) study suggested that grandiose narcissism was not associated with ED pathology, when vulnerable narcissism was controlled. However, parental invalidation had a positive indirect effect with ED pathology, via vulnerable narcissism which seems to have stronger association with

ED than grandiose narcissism (Sivanathan, 2019). In a pilot study, Jackson et al. (1992) examined the relationship between narcissism and body image in 307 undergraduate students. They showed that narcissistic individuals pay more attention to their appearance and fitness and therefore, are more involved in behaviors related to appearance and fitness (e.g., diet and exercise) (Jackson, 1999). Alizadeh et al. (2015) reported that body composition and physical conditions of both types of narcissism had a significant relationship with body perception (Alizadeh ,2015). Since regular exercise is very common in athletes, it seems reasonable that athletes may exhibit higher narcissistic behaviors (Alizadeh, 2015).

ED has been associated with negative psychological consequences and recognizing negative outcomes will provide a framework for future investigations of narcissism and exercise dependence components. Moreover, considering the lack of studies in this context, this study aimed to investigate the effect of exercise dependence and narcissism on EDs in male bodybuilders.

Materials and methods

250 male bodybuilders were randomly selected from city clubs (Urmia, Iran), through multistage cluster sampling. The included athletes have been training continuously through last year and at least three sessions per week. The mean age of the subjects was 26.8 years with a standard deviation of 5.94. Three questionnaires were used for data collection:

Narcissistic personality questionnaire: The current form of the narcissistic personality questionnaire has 40 questions and assesses the six components of authority, superiority, exploitativeness, legitimacy, self-sufficiency and self-esteem. This questionnaire was developed by Raskin and Hall in 1979 and using the split-half method, a reliability coefficient of 0.80 was reported. The Persian version of this questionnaire is narcissistic personality inventory (NPI)-40 that is validated in different studies (Raskin, 1997). Each question contains two-choice which is given a score and respondents chose one of two that is close to their characteristics. The sum-score above 20 indicates the narcissistic personality aspect.

Exercise dependence scale 21 questionnaire: The questionnaire was developed by Hausenblas and Downs (2002) and contains 21 questions, which are scored on a six-point Likert scale (one = never to six = always) (Hausenblas, 2002). A higher score indicates symptoms of exercise dependence and is manifested by observing at least three or more of the seven components. The validity and reliability of this tool had been evaluated in numerous studies. In the present study, the reliability coefficient of this scale was 92% using Cronbach's alpha. The results obtained from confirmatory factor analysis (goodness of fit index (GFI) = 0.9, adjusted goodness of fit index = 0.78 and root mean square error of approximation (RMSEA) = 0.74) indicate that the model fits well with the data. The results also showed that sample size was sufficient for factor analysis.

Eating disorder questionnaire: Eating attitude test EAT-26 items has been widely used as a self-assessment screening tool for eating-related attitudes and behaviors and has been proven to be effective in identifying neuropsychiatric anorexia and overeating (Garner, 1989). Each item of the questionnaire is graded on a six-point scale (always, often, usually, sometimes, rarely and never), while always, often and usually are scored three, two and one and the remaining three options (sometimes, rarely, and never) are scored zero. The screening score is derived from the sum of the scores, therefore, the EAT-26 score can range from zero to 78 and score 20 and above is considered as cut-off point. Nobakht (1998) had examined the content validity and reliability and calculated reliability coefficient using Pearson's correlation coefficient. According to their results, the correlation coefficient between the scores obtained from the two stages of this questionnaire was 0.91 in the study group, indicating a desirable reliability (Nobakht, 1998).

Data analysis was performed using descriptive and inferential indices including mean and standard deviation, correlation coefficient and multivariate regression by SPSS 22 software (SPSS Inc., Chicago, Illinois, USA) and p-value less than 0.05 was considered as significant.

Theory/calculation

Researches indicate that ED is associated with numerous consequences and negative outcomes that affects narcissism and exercise dependency in athletes. Regarding the lack of studies in this context, this study aimed to investigate the effect of exercise dependence and narcissism on EDs in men bodybuilders to take the necessary precautions for preventing nutritional or personality problems.

Results

Descriptive indices (mean and standard deviation) of research variables are presented in Table 1. Among the components of exercise dependency, withdrawal and intention had the highest and lowest mean 22.99 ±3.06 and 19.31 ±3.20 respectively. Among the components of narcissism, authority has the highest mean (4.56 ±1.89) and vanity has the lowest mean (0.91 ±0.74). In addition, dieting had the highest mean (24.26 ±4.35) and oral control had the lowest mean (16/38 ±3.32) among the components of ED.

Pearson correlation coefficient was used to examine the relationship between the components of exercise dependence, narcissism and ED in the participants. As presented in Table 2, dependence on exercise and its components have a significant positive relationship with ED, and its components ($P < 0.01$). Narcissism and its components had a significant positive relationship with ED components ($P < 0.01$).

Table 1. Descriptive indicators of the components of exercise dependence, narcissism, and EDs in the subjects

Variable	Component	Mean	Standard deviation
Exercise dependence	Withdrawal	22.99	3.06
	Continuance	19.34	3.36
	Tolerance	21.38	3.65
	Lack of control	21.32	4.38
	Reduction in other activities	20.05	4.46
	Time	21.36	3.31
	Intention effect	19.31	3.20
Narcissism	Authority	4.56	1.89
	Exhibitionism	1.38	1.26
	Superiority	1.74	1.27
	Exploitativeness	1.76	1.31
	Entitlement	2.48	1.54
	Self-Sufficiency	1.89	1.74
	Vanity	0.91	0.74
Eating disorder	Dieting	24.26	4.35
	Bulimia	19.36	3.38
	Oral control	16.38	3.32

Table 2. Correlation coefficients of the components of exercise dependence and narcissism with ED in the subjects (* p < 0.001)

Variable	Dieting	Bulimia	Oral control
Withdrawal	0.453*	0.426*	0.540*
Continuance	0.523*	0.424*	0.420*
Tolerance	0.562*	0.386*	0.459*
Lack of control	0.520*	0.487*	0.443*
Reduction in other activities	0.623*	0.445*	0.474*
Time	0.470*	0.433*	0.462*
Intention effect	0.562*	0.452*	0.421*
Authority	0.428*	0.530*	0.482*
Exhibitionism	0.436*	0.518*	0.442*
Superiority	0.426*	0.450*	0.371*
Exploitativeness	0.378*	0.430*	0.318*
Entitlement	0.375*	0.356*	0.424*
Self-Sufficiency	0.562*	0.521*	0.620*
Vanity	0.412*	0.516*	0.467*

Table 3. Summary of results of multivariate regression analysis of exercise dependence, narcissism and their components in research subjects

Predictive variable	B	ß	T	Level of Significance	R	R^2	F	Level of Significance
Withdrawal	0.290	0.180	3.826	0.0200				
Continuance	0.118	0.085	1.648	0.0010				
Tolerance	0.654	0.386	8.378	0.0010	0.68	0.462	52.64	0.0001
Lack of control	0.122	0.086	1.645	0.0100				
Reduction in other activities	0.280	0.175	3.864	0.0010				
Time	0.310	0.186	3.445	0.0010				
Intention effect	0.415	0.216	3.946	0.0001				
Authority	0.360	0.189	3.322	0.0010				
Exhibitionism	0.116	0.079	1.623	0.0010				
Superiority	0.385	0.217	3.952	0.0001				
Exploitativeness	0.125	0.086	1.648	0.0100				
Entitlement	0.389	0.207	4.450	0.0001				
Self-Sufficiency	0.346	0.235	5.324	0.0030				
Vanity	0.250	0.172	3.853	0.0001				

Multivariate correlations were used to investigate the predictive role of exercise dependence and narcissism in ED. The minimum and maximum beta (ß) values were significantly related to the components of exhibitionism (ß = 0.079, P = 0.001) and tolerance (ß = 0.386, P = 0.001) respectively (Table 3). Other components reported in the table explain 46% of the variance in ED (P < 0.01).

Discussion

The aim of this study was to investigate the effect of exercise dependence and narcissism components on EDs in male bodybuilders. The results demonstrated that, dependence on exercise and narcissism and their components are associated with ED prognosis. These results are correlated with previous studies by Campbell et al. (2010), Costa, Oliva (2012), Cook et al. (2015). In a research in 2002, Penas, Leal, Waller stated that there is a significant relationship between excessive exercise and a wide range of narcissistic traits and exercise can affect EDs. In western culture, generally being thin is considered advantageous (Penas-Lledó, 2002), therefore, when narcissistic individuals engage in a self-defense activity that increase their self-confidence, it will likely be an over-focus on body and physical appearance (Kohut, 2013). Such a defensive process is similar to the cognitive process of compensatory schemas, which is related to the underlying features of EDs (Young, 1994).

In individual with elements of narcissism, it can be assumed that, they intend to deal with the threatening factors of self-confidence through exercise (e.g., criticism and negative emotions) and enhances self-confidence by improving appearance (Campbell, 2010). People who attend the clubs are usually very dissatisfied with their appearance and tend to do more work out (Choi, 2002). This may be an effector in the ED itself, in accordance with findings of present study. Lipsey et al. (2006), also reported that the relationship between exercise and EDs in non-athletes with EDs was clinically less than elite athletes. For example, unprofessional athletes, in particular high school students, have a lower risk of EDs than their athletic peers. Indeed, if participants in the exercise are unaware of their body weight, it may be difficult to assess the potential risks or protective nature of participating in the exercise (Lipsey, 2006).

It can be concluded that in societies where people are exposed to social, cultural and media pressures on beauty and fitness, various kinds of ideal beauty and body shape criteria are becoming more prevalent which lead to a constant self-evaluation and misjudgment of the body. Therefore, to relieve this constant concern, one resorts to body management behaviors such as diet, medical manipulation or exercise. These coping behaviors may also lead to negative psychological consequences, such as EDs.

Recent studies have shown that people have different motivation to participate in sports clubs (Farahani, 2012). Noorbakhsh, Shafi Nia, Golchinkoohi (2010) stated that the motivation behind participating in an exercise is the urge to increase or maintain physical fitness and well-being, experience happiness, improve physical appearance, social status, self-confidence and psychological benefits (Noorbakhsh, 2010). Therefore, the difference in the amount of exercise, especially among athletes, is related to the difference in their motivation. Some athletes misuse a variety of medications to increase strength, muscle growth and physical appearance. As a result, this has become a common issue in societies and has created numerous irreparable social, economic, health, cultural, psychological and physical consequences (Yavari, 2013). So, to take the necessary precautions for preventing various personality problems and potential deviations, managers and authorities are to develop appropriate plans and programs. These programs should be conducted through various channels, including schools, universities, mass media, counseling centers, and the Ministry of Sports and Youth. This way, young people, especially competent and well-respected athletes, will be well-educated in terms of personality and psychology for the future (Rasouli, 2021). One of the limitations of this study is its implementation merely in men's society, whereby its generalization to women's society may not be logical. The present study was carried out among bodybuilders and it is suggested that similar researches should be conducted among athletes of other fields to extend the results. In addition, self-report questionnaires, which are utilized in this study, have limitations when used in narcissistic individuals due to their unrealistic and extravagant claim of self-esteem, albeit they may be in denial of their weaknesses (Gordon, 2010).

Conclusion

This study suggests that nutritional behaviors can be promoted by improving narcissistic tendencies and dependency on exercise. Determining the components of behavior, narcissism and dependency will ascertain the main contributors, thus, purposeful implementations can be designed.

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Reference

Alizadeh, L., Hoseini, F.S., Mohammadzadeh, H. (2015). The relationship between narcissism and body perception in male bodybuilders. *Journal of Sport Management and motor behavior*, *11* (21), 75–82.

Bratland-Sanda, S., Martinsen, E.W., Rosenvinge, J.H., Ro, O., Hoffart, A., Sundgot-Borgen, J. (2011). Exercise dependence score in patients with longstanding EDs and controls: the importance of affect regulation and physical activity intensity. *European EDs Review*, *19* (3), 249–255.

Brosof, L.C, Williams, B.M., Levinson, C. (2020). Exploring the contribution of exercise dependence to ED symptoms. *International Journal of EDs*. *53* (1), 123–127. DOI: 10.1002/eat.23156.

Campbell, M., Waller, G. (2010). Narcissistic characteristics and eating-disordered behaviors. *International Journal of EDs*. *43* (6), 560–564.

Choi, P., Pope, H., Olivardia, R. (2002). Muscle dysmorphia: a new syndrome in weightlifters. *British Journal of Sports Medicine*, *36* (5), 375–376.

Costa, S, Oliva, P. (2012). Examining relationship between personality characteristics and exercise dependence. *Review of Psychology*, *19* (1), 5–11.

Davis, C. (1992). Body image, dieting behaviours, and personality factors: A study of high-performance female athletes. *International Journal of Sport Psychology*, *23* (3), 179–192.

Farahani, A., Salamat, N., Goudarzi, M. (2012). Cheking customer satisfaction and private fitness clubs of Gorgan. *Sports Management Studies*, *16*, 143–156.

Fox, K.R. The physical self and processes in self-esteem development. 1997.

Garner, D.M., Garfinkel, P.E. (1989). Body image in anorexia nervosa: Measurement, theory and clinical implications. *The International Journal of Psychiatry in Medicine*, *11* (3), 263–284.

Gordon, K.H., Dombeck, J.J. (2010). The associations between two facets of narcissism and ED symptoms. *Eating behaviors*, *11* (4), 288–92.

Hausenblas, H.A., Downs, D.S. (2002). Relationship among sex, imagery and exercise dependence symptoms. *Psychology of Addictive Behaviors*, *16* (2), 169.

Jackson, L.A., Ervin, K.S., Hodge, C.N. (1999). Narcissism and body image. *Journal of Research in Personality*, *26* (4), 357–370.

Kohut, H. The analysis of the self: A systematic approach to the psychoanalytic treatment of narcissistic personality disorders: University of Chicago Press. 2013.

Lejoyeux, M., Avril, M., Richoux, C., Embouazza, H., Nivoli, F. (2008). Prevalence of exercise dependence and other behavioral addictions among clients of a Parisian fitness room. *Comprehensive Psychiatry*, *49* (4), 353–358.

Lipsey, Z., Barton, S.B., Hulley, A., Hill, A.J. (2006). "After a workout…" Beliefs about exercise, eating and appearance in female exercisers with and without ED features. *Psychology of Sport and Exercise*, *7* (5), 425–436.

Nobakht, M. (1998). Epidemiology of EDs in high school girl students in Tehran. (Master’s thesis).

Noorbakhsh, P., Shafeinia, P., Golchin koohi, M.A (2010). comparison of competitive and non-competitive male athletes self-appear in their field of bodybuilding and its relationship with body dissatisfaction. *Exercise Science*, *2* (4), 31–47.

Penas-Lledó, E., Vaz Leal, F.J., Waller, G. (2022). Excessive exercise in anorexia nervosa and bulimia nervosa: relation to eating characteristics and general psychopathology. *International Journal of EDs*, *31* (4), 370–375.

Raskin, R.N., Hall, C.S. (1979). A narcissistic personality inventory. *Psychological reports*, *45* (2): 590.

Rasouli, A., Mohiti, S., Javadi, M., Panjeshahin, A., Kazemi, M., Shiri-Shahsavar, M.R. (2021). The effect of daily fast food consumption, family size, weight-caused stress, and sleep quality on eating disorder risk in teenagers. *Sleep and Breathing*, *25* (3), 1527–33.

Sachs, M.L. (1981). Running therapy for the depressed client. *Topics in Clinical Nursing*, *3*, 770–786.

Scharmer, Ch., Gorrell, S., Schaumberg, K., Anderson, D. (2019). Compulsive exercise or exercise dependence? Clarifying conceptualizations of exercise in the context of ED pathology. *Psychology of Sport and Exercise*, (46): 101586.

SHafiee, H., Saffarinia, M. (2011). Narcissism, self-esteem, and dimension of aggression in adolescents.

Sivanathan, D., Bizumic, B., Rieger, E., Huxley, E. (2019). Vulnerable narcissism as a mediator of the relationship between perceived parental invalidation and ED pathology. *Eating and weight disorders: EWD* DOI: 10.1007/s40519-019-00647-2.

Stice, E., Shaw, H.E. (2002). Role of body dissatisfaction in the onset and maintenance of eating pathology: A synthesis of research findings. *Journal of psychosomatic research*, *53* (5), 985–993.

Yarock, S.R. (1993). Understanding chronic bulimia: A four psychologies approach. *The American journal of psychoanalysis*, *53* (1), 3–17.

Yavari, Y. (2013). Comparison of narcissism and beliefs about appearance, between professional and amateur bodybuilders. *Sports Psychology Studies*, *7*, 49–62.

Young, J.E. (1994). Cognitive therapy for personality disorders: A schema-focused approach (rev: Professional Resource Press/ Professional Resource Exchange.

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