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KEY KINEMATIC COMPONENTS FOR OPTIMAL BASKETBALL FREE THROW SHOOTING PERFORMANCE

Dimitrije Cabarkapa[A,B,C,D,E]

Jayhawk Athletic Performance Laboratory – Wu Tsai Human Performance Alliance, University of Kansas, Lawrence, KS, USA
ORCID: 0000-0001-9912-3251 | e-mail: dcabarkapa@ku.edu

Andrew C. Fry[A,B,C,D,E]

Jayhawk Athletic Performance Laboratory – Wu Tsai Human Performance Alliance, University of Kansas, Lawrence, KS, USA
ORCID: 0000-0001-8171-7684

Kevin M. Carlson[A,B]

College of Arts and Sciences, Des Moines, IA, USA
ORCID: 0000-0003-4154-4664

John P. Poggio[A,C]

Department of Educational Psychology, University of Kansas, Lawrence, KS, USA
ORCID: 0000-0001-9432-4871

Michael A. Deane[A,D]

Jayhawk Athletic Performance Laboratory – Wu Tsai Human Performance Alliance, University of Kansas, Lawrence, KS, USA
ORCID: 0000-0002-0954-7649

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract The purpose of this study was to determine the difference in five kinematic variables (internal knee and elbow angles, elbow height, forearm angle from vertical, and shoulder flexion angle at ball release) between proficient and non-proficient free throw shooters and which variables had the greatest contributions to a successful free throw shooting outcome. Seventeen male basketball players shoot three sets of 10 free throws with a two-minute break between each set. A three-dimensional motion tracking system composed of 17 sensors sampling at 60 Hz was used for data collection. Proficient free throw shooters had greater knee and elbow flexion, lower elbow height, and a smaller forearm angle compared to non-proficient shooters. These results explained 89.5% of the total variance. While maintaining the optimal range of these kinematic variables allows each subject to reach an appropriate level of free throw shooting performance, the key variable capable of distinguishing between made and missed shots within the proficient group of shooters was the forearm angle. Positioning the forearm parallel, or close to parallel, with an imaginary vertical line during the preparatory phase of the shooting motion accounted for 23.9% of the total variance and was associated with a greater number of made shots.

Key words coaching, sport science, shooting technique, analysis

Introduction

Basketball is considered one of the most popular sports worldwide. Fast pace, high scoring, and highly skilled movements significantly contribute to the overall attractiveness of this sport. Since 1891, when James Naismith invented the game of basketball, numerous modifications have been made in order to improve the flow, scoring, and safety of the game while free throw rules have stayed unchanged for almost a century.

Previous research has shown that free throw performance is one of the key factors for determining winning or losing within some of the highest levels of basketball competition (Sampaio, Janeira, 2003). During a regular basketball season, results of four to six games have been solely determined by the in-game players' free throw shooting performance (Hays, Krause, 1987). The team's ability to secure and make more free throw attempts, as well as achieve higher overall shooting percentage, has been correlated with the positive final game outcome (Csatalsay, O'Donoghue, Hughes, Dancs, 2009; Sampaio, Janeira, 2003; Trninic, Dizdar, Luksic, 2002). Additionally, it has been shown that an optimal free throw shooting performance is even more critical close to the end of the game (Sampaio, Janeira, 2003). Currently, based on general coaching norms and previous research findings, it is considered that the average success rate for adult free throw shooting performance is approximately 70% (Mullineaux, Uhl, 2010; Sampaio, Janeira, 2003; Tran, Silverberg, 2008). Depending on the in-game requirements and the playing style, the percentage of total game points scored from the free throw line can range between 19–25% (Branch, 2009; Kozar, Vaughn, Whitfield, Lord, Dye, 1994; Sampaio, Janeira, 2003). Hence, considering the impact that successful free throw shooting performance can have on the overall number of scored points and the final game outcome, it is not surprising that basketball coaches dedicate a considerable amount of time to coaching this shooting motion.

Even though the free throw shot has been considered one of the easiest uncontested shooting motions in the game of basketball (Okubo, Hubbard, 2006), many players on various levels of competition struggle with its optimal and consistent execution. A considerable amount of scientific literature has been focused on addressing the optimal free throw shooting trajectory from a theoretical point of view, and its kinematic components that could lead to the successful free throw outcome (Brancazio, 1981; Hamilton, Reinschmidt, 1997; Huston, Grau, 2003; Okubo, Hubbard, 2006; Tan, Miller, 1981; Tran, Silverberg, 2008). Two of the most commonly observed variables necessary for the optimal ball trajectory during a free throw shot include release angle and release speed (Hamilton, Reinschmidt, 1997; Hudson, 1985; Miller, Bartlett, 1996; Tan, Miller, 1981; Tran, Silverberg, 2008). Hamilton and Reinschmidt (1997) found that the optimal release angle and ball speed for a basketball free throw shot should be 60 degrees and 7.3 $m \cdot s^{-1}$, respectively. Tan and Miller (1981) obtained similar conclusions regarding the optimal projection velocity magnitudes; however, their theoretical estimations for the angle of basketball projection were lower by approximately nine degrees. Huston and Grau (2003) took a step further with an attempt to theoretically determine the optimal shooting kinematics for various shooting strategies such as free throw, standard shot, and lay-up. The estimated free throw release angle of 51.2 degrees exhibited almost identical agreement with the findings of Tan and Miller (1981), while the minimal release speed was estimated to be 7.14 $m \cdot s^{-1}$ (Huston, Grau, 2003). Furthermore, when producing hundreds of thousands of three-dimensional free throw basketball trajectory simulations, Tran and Silverberg (2008) obtained similar findings while adding that if the release angle falls under 52 degrees, the player will be more susceptible to error. Considering that it is almost impossible to produce the identical body motion multiple times in a row, Huston and Grau (2003) estimated the allowable margin of error for each of these variables. They determined that the allowable deviations for the release angle are roughly seven degrees and the ball speed 0.15 $m \cdot s^{-1}$ (Huston, Grau, 2003). Thus, failure to achieve these optimal kinematic

magnitudes and stay within the recommended range could potentially lead to an unsuccessful free throw shooting attempt. While some may assume that these kinematic characteristics are only prominent within high skill basketball players, Hudson's (1985) findings reveal nonexistent differences in both release angle and release speed between low, moderate, and high skill free throw shooters, suggesting that there might be other kinematic contributors affecting the successful execution of the free throw shooting motion.

While the disagreement in release angle and speed between the previously mentioned studies is minimal, the inability to achieve the optimal shooting trajectory may also be attributed to the difference in the estimated average basketball player height incorporated into their theoretical computations. Hamilton and Reinschmidt (1997) indicated that, besides optimal release angle and speed, individual anthropometric characteristics may be another influential factor that influence overall shooting accuracy. For a 6 ft (182.9 cm) basketball player, the average release height is estimated to be approximately 7 ft (2.134 m) (Huston, Grau, 2003; Tran, Silverberg, 2008). Tran and Silverberg's (2008) findings indicate that greater height of ball release is related to an enhanced basketball shooting performance. Given the equal shooting ability, Brancazio (1981) further supports Tran and Silverberg's findings and denotes that taller players tend to have an advantage in free throw shooting performance due to the enlarged margin of error caused by the higher point of release. It is assumed that these observations may be mainly induced by the lower speed of release and reduced force production requirements (Brancazio, 1981). However, these findings contradict some of the stereotypical beliefs, advocating that taller players tend to be poorer free throw shooters (Robinson, 2016). It is generally assumed that due to a higher release point, a taller player needs to make up for the ball trajectory which requires additional muscular control (Robinson, 2016). While the height contribution to the optimal free throw shooting accuracy is still an underexamined idea, sport scientists need to be conscious of a possibility that designated playing positions more than players' heights are affecting the free throw shooting proficiency. Miller and Bartlett (1996) found more consistent changes in shooting kinematic patterns with adjustments in shooting distances for guards when compared to centers. These findings suggest that shorter players might be more accustomed to shots further away from the basket, such as a free throw, due to their on-court playing requirements (Miller, Bartlett, 1996).

Another factor that has been considered to play an important role for proper free throw shooting mechanics is the backspin. Previous research has found that a free throw shot with more backspin has greater chances to result in a positive outcome (Brancazio, 1981; Hamilton, Reinschmidt, 1997; Okubo and Hubbard, 2006). When a greater margin of error might be created with player's inability to achieve the optimal angle, height or speed at the time point of the ball release, applying an appropriate amount of backspin can serve as a correction factor that may make up for the lack of other kinematic properties (Okubo, Hubbard, 2006). Considering that it is uncommon for an average basketball player to make a series of perfect free throw shots without touching the front or back part of the rim, applying back spin might be a critical component. Based on the laws of physics, when a basketball with an appropriate amount of backspin touches the rim, it will alter its translational and rotational motions (Brancazio, 1981). Due to this effect, the ball can roll into the rim even though the shot trajectory was not ideal (Brancazio, 1981). Several other reports further support the importance of the backspin while suggesting that players should aim closer to the back of the rim as this approach can elicit a higher free throw shooting accuracy (Hamilton, Reinschmidt, 1997; Okubo, Hubbard, 2006; Tran, Silverberg, 2008). Additionally, while backspin is important for proper shooting trajectory, the force exerted on a rapidly spinning cylinder through the air in a direction at an angle to the axis of spin, known as the Magnus effect, could potentially influence the optimal free throw trajectory. Huston and Grau

(2003) estimated that the Magnus effect with a 7.14 $m \cdot s^{-1}$ ball release speed, is capable of exerting force about 4% of the overall basketball weight. Although, when considering that average time for free throw shot is approximately one second, the effect of air resistance within this small amount of time might not be capable of eliciting significant modifications to the optimal ball trajectory (Brancazio, 1981).

Based on the previously mentioned research findings, we understand that there is a considerable amount of scientific literature addressing some of the major factors necessary for the optimal free throw shooting trajectory. While their validity and importance remain intact and unchallenged, the practical segment of sports science that addresses the influence of some of the highly emphasized coaching cues for kinematic variables that players can instantaneously implement to improve free throw shooting performance is almost non-existent. Hence, the purpose of this study was to investigate the difference in these kinematic variables between proficient and non-proficient free throw shooters, as well as to determine which variables have the greatest contribution to the successful free throw shooting outcome.

Methods

Subjects

Seventeen healthy recreationally active male basketball players (height = 182.7 ±8.9 cm, weight = 88.9 ±6.5 kg, age = 29.6 ±10.1 years) volunteered to participate in this research study. Each participant completed the informed consent form prior to any testing procedures. Participants with any musculoskeletal injuries were not permitted to participate in this study. All procedures performed in this study were previously approved by the University's Institutional Review Board.

Procedures

Upon arrival to the testing facility, participants performed a standardized warm-up procedure consisting of a five-minute treadmill run at a moderate intensity and a set of dynamic exercises involving high knees, butt-kicks, lunge-and-twist, lateral slides, high skips, and lateral lunges. Each participant was individually familiarized with a three-dimensional motion tracking system (XSENS MVN Awinda, Enschelde, Netherlands) used for the data collection. The motion tracking system, sampling at 60 Hz, contained 17 wireless sensors secured with a specially designed tight Lycra suit and a set of mounting Velcro straps. Each sensor was composed of an accelerometer, gyroscope, magnetometer, and barometer. All sensors were individually placed based on the manufacturer's instructions on the following body locations: left and right foot (middle of the bridge of foot), left and right shank (anterior surface of the tibia), left and right lateral mid-thigh (superior to the knee), pelvis (posterior sacrum), sternum (middle of the chest), left and right shoulder (mid-scapula), left and right upper arm (lateral side superior to the elbow), left and right posterior forearm (proximal to the wrist), left and right posterior hand, and head (middle of the forehead by frontal eminence). After placement of the sensors, the motion tracking system was calibrated following the detailed instructions provided by the manufacturer. Each participant was provided with a size 7 standardized basketball (75 cm), while the goal was positioned at a standardized height of 10 feet (3.05 m). The experimental set-up is shown in Figure 1. Participants shot three sets of 10 free throws with a two-minute break between each set to assure adequate recovery. Throughout all testing procedures, a rebounder was present in order to preserve participant's energy and assure an optimal focus directed towards the free throw shooting motion. A research

assistant kept track of the overall number of free throw shots that the participant took, as well as which specific shots were missed. To eliminate any possible distractions caused by other participants in the testing facility, each participant individually performed the testing procedures. Recorded performance variables include number of made and missed free throw shots, and the percentage of made free throws. Participants making ≥70% of their free throw shots were categorized as *"proficient"*, and those making <70% were categorized as *"non-proficient"*, based on the feedback from our panel of experts.

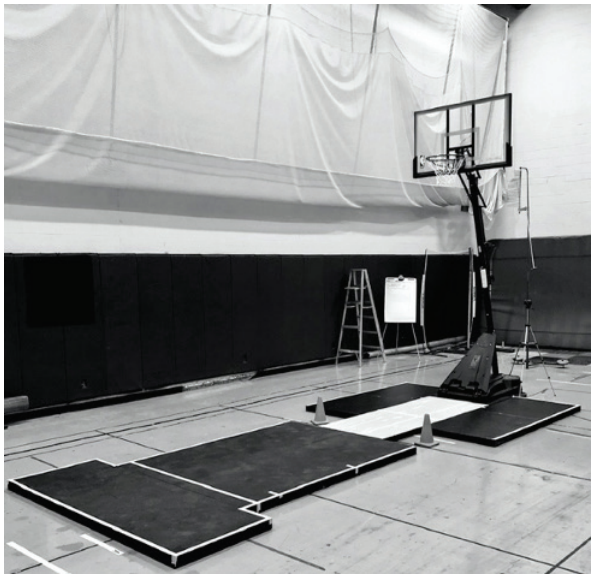

Figure 1. Experimental set-up

Variables

This study was focused on five free throw kinematic variables, selected after extensive conversations with an expert panel of highly reputable basketball coaches, and obtaining their input regarding key factors considered crucial for the optimal free throw shooting performance. The first dependent variable is the *knee angle* (Figure 2, angle a) which is defined as the maximum internal angle at the knee joint during the preparatory phase of the free throw shooting motion. The second dependent variable is the *elbow height* (Figure 2, line b), defined as the perpendicular distance between the olecranon process and the ground immediately prior to the free throw initiation. The third dependent variable is *elbow angle* (Figure 2, angle c), defined as the internal angle of the elbow at the initial stage of the free throw shooting motion. The fourth dependent variable is the *forearm angle* (Figure 2, angle d), defined as the angle between the long axis of the forearm and an imaginary vertical line at the initiation of the free throw shooting motion. This variable is used to determine the magnitude of the lateral elbow deviation. If the forearm is parallel with the imaginary vertical line, the forearm angle value will be equal to 0°. The fifth dependent variable is the *shoulder angle* (Figure 2, angle e), which is the angle between the long axis of the arm segment and

an imaginary vertical line that passes right through the center of the glenohumeral joint at the time point of the ball release. The value for the shoulder angle is equal to 0° when an individual is standing in the standard anatomical position with the upper limbs parallel to the torso.

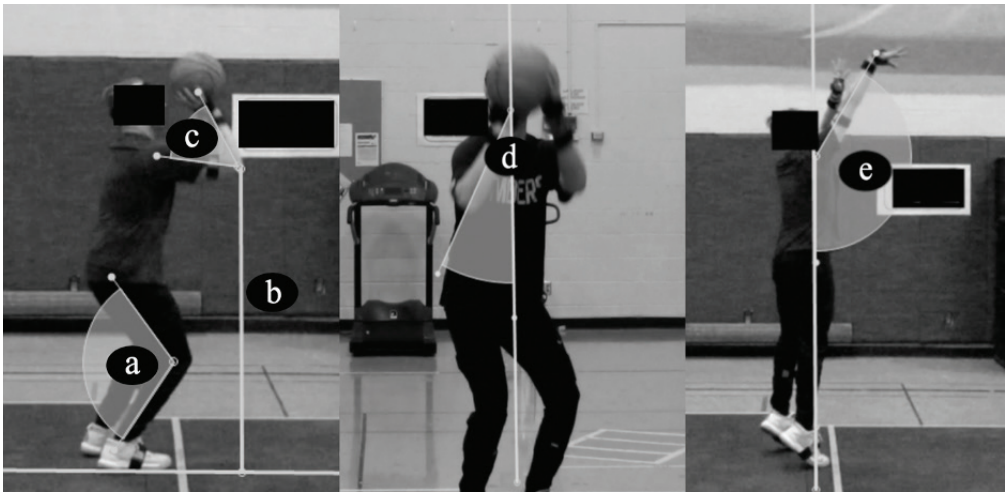

Figure 2. Graphical representation of measured dependent variables: (a) knee angle, (b) elbow height, (c) elbow angle, (d) forearm angle, (e) shoulder angle

Statistical Analysis

Descriptive statistics and standard deviations ($\bar{x} \pm SD$) were calculated for each of the dependent variables. A multivariate Hotelling's T-Squared test was used to detect the difference in the dependent variables between proficient (≥70%) and non-proficient (<70%) free throw shooters. Although the purpose of this study was not to develop a prediction equation and determine the optimal shooting kinematics, a full-model discriminant function analysis was used to quantify the contribution of each of the dependent variables separating proficient from non-proficient free throw shooters. Additionally, a multivariate Hotelling's T-Squared test was used to determine the difference in the dependent variables between made and missed free throw shots within just the group of proficient free throw shooters (≥70%). Levene's test was used to examine if the data sets met the homogeneity of variance assumption. Statistical significance was set a priori to $p < 0.05$. All statistical analyses were completed with SPSS Version 25.0 software statistical package (SPSS Inc. Chicago, IL, USA).

Results

Mean values and standard deviations ($\bar{x} \pm SD$) for each of the dependent variables for both proficient (≥70%) and non-proficient (<70%) free throw shooters are presented in Table 1. The average free throw shooting percentage for proficient and non-proficient group of free throw shooters was 82.7 ±7.9% and 52.4 ±13.4%, respectively. The total number of free throw shots that subjects performed was 495, from which 295 shots have been attempted

by proficient and 200 by non-proficient free throw shooters. In order to assure equal sample sizes and avoid violation of homogeneity of variance, 95 samples from the proficient group of shooters have been randomly removed by the SPSS software. Hotelling's T-Squared test indicated a highly significant difference ($p < 0.001$) between all of the dependent variables examined in this study, except for the shoulder angle variable ($p > 0.05$).

Table 1. Mean and standard deviations ($\bar{x} \pm SD$) for all dependent variables between proficient (≥70%) and non-proficient (<70%) free throw shooters

Dependent variables	Proficient shooters	Non-proficient shooters
Knee flexion (deg)	108.5 ±9.8	117.9 ±16.3*
Elbow height (cm)	147.6 ±9.3	153.4 ±16.5*
Elbow angle (deg)	71.9 ±5.6	80.5 ±6.3*
Forearm angle (deg)	7.9 ±7.2	19.8 ±17.6*
Shoulder angle (deg)	123.4 ±15.3	124.4 ±14.2

* Significant difference ($p < 0.05$).

Based on the standardized discriminant function analysis weights, the highest prominence in predicting proficient vs. non-proficient free throw shooters was attributed to the elbow angle and forearm angle variables. The magnitudes of standardized discriminant function coefficients (beta weights), and the percentage of total and explained variance for each of the dependent variables examined in this study are presented in Table 2. The computed discriminant function analysis was able to correctly classify free throw shooters in the proficient or non-proficient category based on the observed dependent variables in 89.5% cases. The detailed classification results for predicted group membership are presented in Table 3.

Table 2. Standardized discriminant function coefficients, and the percentage of explained and total variance for each of the dependent variables examined in this study

Dependent variables	Standardized coefficients	Percentage of explained variance	Percentage of total variance
Knee flexion (deg)	–0.091	3.2	2.9
Elbow height (cm)	–0.604	21.5	19.2
Elbow angle (deg)	1.151	41.0	36.7
Forearm angle (deg)	0.750	26.7	23.9
Shoulder angle (deg)	–0.213	7.6	6.8
Total		100.0	89.5

Canonical correlation = 0.723 (effect size = 0.523).

Table 3. Classification results for predicted group membership

Actual Group	Predicted group membership		Number of cases
	non-proficient	proficient	
Non-proficient	176 (88%)	24 (12%)	200
Proficient	18 (9%)	182 (91%)	200

89.5% of subjects correctly classified ($p < 0.05$).

Mean values and standard deviations ($\bar{x}$ ± SD) for each of the dependent variables between made and missed free throw shots within the proficient (≥70%) group of shooters are presented in Table 4. The total number of made and missed free throw shots was 157 and 43, respectively. Levene's test did not reach the level of statistical significance ($p > 0.05$) for all of the variables examined in this study. The only statistically significant difference in the dependent variables between made and missed free throw shots within a group of proficient free throw shooters was present for the forearm angle variable ($p = 0.004$).

Table 4. Mean and standard deviations ($\bar{x}$ ± SD) for all dependent variables between made and missed free throw shots within proficient (≥70%) free throw shooters

Dependent variables	Made shots	Missed shots
Knee flexion (deg)	108.1 ±10.1	110.0 ±8.3
Elbow height (cm)	147.7 ±9.2	147.2 ±9.9
Elbow angle (deg)	72.3 ±5.3	70.5 ±6.5
Forearm angle (deg)	7.2 ±5.6	10.7 ±10.1*
Shoulder angle (deg)	123.5 ±15.8	122.7 ±13.7

* Significant difference ($p < 0.05$).

Discussion

Based on the findings of this study, we identified some distinguishable kinematic differences between proficient and non-proficient free throw shooters. Proficient free throw shooters implemented some of the highly emphasized coaching cues during the preparatory phase of the shooting motion, which ultimately lead to increased shooting accuracy. Considering that knee flexion allows for the optimal lower body leverage and power contribution, the proficient group of shooters had significantly lower knee angles values compared to the non-proficient group. Despite the minimal or almost non-existent impact on the overall shooting ability prediction model, greater knee flexion during the preparatory phase of the free throw shooting motion may play an important role in achieving the desired level of free throw shooting accuracy. Our observations are in agreement with the findings of Cabarkapa, Fry, Poggio, Deane (2021) that used video analysis to examine kinematic differences between proficient and non-proficient free throw shooters. In another investigation, the researchers suggested that greater total movement in the knee joint was one of the critical kinematic components for successful free throw shot (Ammar, Chtourou, Abdelkarim, Parish, Hoekelmann, 2016). Unlike observed in the present study, lower flexion in the preparatory phase and greater extension at the release phase of the shooting motion were related to improvements in player's shooting technique and ultimately lead to a greater number of made free throws (Ammar et al., 2016). However, when the difference in the knee angle between made and missed free throw shots was examined within a group of proficient shooters, the knee angle did not demonstrate statistical significance. Similar findings were reported by Uygur, Goktepe, Ak, Karabork, Korkusuz (2010) when they examined the effect of fatigue on kinematics of basketball free throw shooting technique. They found that the knee angle before, after, and at the ball release was not significantly different between made and missed free throw shots (Uygur, Goktepe, Ak, Karabork, Korkusuz, 2010). The inability to observe a difference in knee flexion may be mainly attributed to the cohort of subjects that volunteered to participate in the study. Uygur at al.'s (2010) observations were based on a group of high-level collegiate athletes

that are assumed to have a respectable average free throw percentage, which based on their free throw shooting skill ability, might be comparable to the proficient group of shooters tested in the present study.

Two dependent variables that demonstrated the greatest impact in predicting between proficient and non-proficient free throw shooters were elbow flexion and forearm angle. Proficient shooters had greater elbow flexion and less lateral elbow deviation from the imaginary vertical axis when compared to the non-proficient group of free throw shooters. While to date, no research has specifically focused on the importance of these variables for proper shooting mechanics and their influence on the optimal shooting trajectory, Mullineaux and Uhl (2010) examined the coordination-variability and kinematic differences between made and missed free throw shots within a cohort of elite collegiate basketball players. They found that the elbow kinematics influenced the wrist mechanics though velocity-dependent-torques (Mullineaux, Uhl, 2010). Although Miller and Bartlett (1996) focused on examining the kinematic differences between short, mid-range, and long-range basketball shots through high-speed videography, their findings further support the importance of the elbow-wrist alignment and indicate that elbow extension for both guards and forwards was related to the increased release speed of the ball. Hence, considering the importance of proper backspin during the release phase of the free throw shot (Brancazio, 1981; Hamilton, Reinschmidt, 1997; Okubo, Hubbard, 2006), we can assume that our data builds upon the previously mentioned literature. Proper elbow positioning may allow for the optimal amount of backspin applied on the ball through proper kinematic chaining at the time point of ball release. Greater elbow flexion can potentially increase the force production necessary to push the ball away from the body while minimal to no forearm deviation would assure that the applied force is completely transmitted through the imaginary vertical axis. Ultimately, failure to achieve the previously mentioned kinematic parameters may impair achieving optimal ball release velocity and height, which has been previously determined as the vital components for the successful outcome of the free throw shot (Hamilton, Reinschmidt, 1997; Hudson, 1985; Miller, Bartlett, 1996; Tan, Miller, 1981; Tran, Silverberg, 2008).

Considering that it is necessary for proficient free throw shooters to maintain all of the other kinematic variables examined in this study within the optimal range, an inability to position the forearm parallel, or as close to parallel, with an imaginary vertical line was as a key factor contributing to an unsuccessful shooting outcome. The difference in the forearm angle between made and missed shooting attempts observed within a proficient group of free throw shooters was minimal; approximately three degrees. While successful execution of the free throw shooting motion requires precise movements influenced by endless number of body kinematic combinations (Hudson, 1985), previously conducted research indicated that margin of error that can distinguish between made and missed free throw shots is very small (Mullineaux, Uhl, 2010). In order to assure that these conditions have been met, we may be able to focus on another variable observed in this study, the elbow height. It is logical that the player's ability to achieve greater elbow flexion and decrease the amount of forearm medial or lateral deviation will lead to lower elbow height. Our findings entirely support these assumptions, indicating that the subjects in the proficient group of shooters had significantly lower elbow heights during the preparatory phase of the free throw shooting motion when compared to the non-proficient group of shooters. While the magnitude of difference was evident, the elbow height demonstrated negative moderate to strong contribution to predicting the player's free throw shooting proficiency. This signifies that higher elbow positioning might be related to increased chances of negative free throw shooting outcome. Thus, based on these findings we may assume that the elbow height might

serve as a rapid estimate for the proper elbow positioning during the preparatory phase of the free throw shooting motion that can be quickly assessed by basketball coaching personnel in a practical setting.

While all of the previously mentioned kinematic variables were significantly different between the proficient and non-proficient group of free throw shooters, the only variable with almost nonexistent difference was the shoulder angle. Our results revealed similar values when compared to the findings of Miller and Bartlett (1996), even though they reported shoulder angle values at the time-point of the ball release for mid-range shots within the free throw shooting line distance. Interestingly, while Goosey-Tolfrey, Butterworth and Morriss (2002) analyzed upper-body kinematics of the free throw shot within a cohort of wheelchair basketball players, the shoulder angle at the ball release detected was almost identical to the values observed in this study. It was suggested that less shoulder flexion leads to greater wrist velocity compensation (Goosey-Tolfrey, Butterworth, Morriss, 2002). Based on these findings we can be assume that despite the inability to observe the difference in the shoulder angle variable between the proficient and non-proficient groups of free throw shooters, both groups were able to attain the optimal shoulder angle magnitudes. Similar findings from Ammar et al. (2016) study focused on examining the difference in shoulder angle at the time-point of ball release between made and missed free throw shots. While the shoulder angle was not significantly different in the present and in the previously mentioned studies, we should not assume that this variable is unnecessary for the successful shooting outcome, especially when considering the slight negative influence of this variable on the free throw outcome prediction model. Thus, we may want to treat this variable as one of the first and most commonly adjusted factors needed to achieve the optimal release angle and velocity.

While all of the previously mentioned variables exhibited significant and a considerable contribution to overall free throw shooting skill prediction, we need to be cautious when interpreting these results. The findings of this study need to be interpreted more as a set of key interdependent kinematic variables, than solely focus on one specific variable. Even though players may be capable of achieving an optimal forearm angle, an inability to control for the optimal magnitudes of the other key kinematic components during the preparatory and completion phase of the shooting motion can result in unsuccessful shooting performance. Considering that this was the first study focused on investigating the influence of some of the highly emphasized free throw coaching cues on the success of the free throw shooting performance, further research is needed to examine the relationship between the variables examined in this study and their effect on the optimal shooting trajectory. Moreover, while our observations were solely based on a cohort of recreationally active basketball players, further research should focus on examining the difference in the same kinematic variables within diverse levels of basketball playing competitions such as high school, collegiate, and professional.

Conclusion

Based on the findings of this study, we can conclude that common coaching cues addressing the proper preparatory and completion phases of the free throw shooting motion can significantly influence the positive outcome of the shot and successfully distinguish between proficient and non-proficient free throw shooters. Proficient free throw shooters exhibited greater knee and elbow flexion, lower relative elbow height, and smaller forearm angle values relative to vertical. While maintaining the optimal range of these kinematic variables can allow a player to reach an acceptable level of free throw shooting performance, the key variable capable of distinguishing between made and missed shots within the proficient group of shooters was forearm angle. The ability to position the forearm

parallel, or close to parallel with the imaginary vertical line during the preparatory phase of the shooting motion may result in a greater number of made free throw shots.

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PERCEPTION AND PRACTICE OF PHYSICAL ACTIVITY AND EXERCISE COUNSELLING IN RENAL CARE TEAM IN NIGERIA

Faatihah Adeyinka Niyi-Odumosu[A, B, C, D, E]

Faculty of Health and Applied Sciences, University of the West of England, Bristol, United Kingdom
ORCID: 0000-0002-6933-4696 | e-mail: faatihah.niyi-odumosu@uwe.ac.uk

Shakrullah Adeniyi Odumosu[B, C, D]

John Walls Renal Unit, Leicester General Hospital, Leicester, United Kingdom
ORCID: 0000-0002-1422-1264

Olufunmilola Leah Dominic[C, D]

Department of Human Kinetics Education, University of Ilorin, Ilorin, Nigeria
ORCID: 0000-0001-7467-5156

Timothy Olusegun Olanrewaju[B, D]

Renal Unit, Department of Medicine, University of Ilorin Teaching Hospital and University of Ilorin, Ilorin, Nigeria
ORCID: 0000-0002-8944-4198

Iliasu Yakubu Seidina[C, D]

Department of Human Kinetics Education, University of Ilorin, Ilorin, Nigeria
ORCID: 0000-0001-6273-1114

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract Introduction. Physical activity (PA) in Chronic Kidney Disease (CKD) requires positive attitude and practice among the renal care team (RCT). The study examined the perceptions and practices of PA and exercise counselling among the RCT in Nigeria.

Methods. The study is 24-item cross-sectional survey on exercise counselling practices on 281 renal care practitioners (females = 149, males = 132; mean age = 42 ±10 years; renal physicians (39%), nurses (50%), and others (11%)) at the 30th annual conference of NANCONF.

Results. Forty two percent did not exercise regularly and 58% engaged in moderate-to-vigorous intensity. 92% agreed sedentary lifestyle is a health risk; 96% agreed that increasing PA is beneficial; and 81% reported that PA is beneficial for patients. 35% recommended PA; 17% referred patients to exercise professionals and 11% facilitated implementation of PA. Barriers to the implementation of PA were lack of motivated patients (75%), resources (69%), funds (66%), and motivated staff (63%).

Conclusion. Perceptions and practices of PA and exercise counselling in the RCT in Nigeria is promising with inconsistencies between beliefs in the benefits of PA and actual implementation. Addressing the reported barriers could improve the recommendation of PA in patient's management.

Key words physical activity, exercise counselling, perception and practice, renal care team, Nigeria

Introduction

Physical activity (PA) influences health through the prevention, control and management of diseases. The recommendations (US Department of Health and Human Services, 2008; World Health Organisation, 2010) emphasise the importance of regular moderate-to-vigorous intensity PA on most days or alternate days of the week with a reduction in sedentary time to the wellbeing. Most health recommendations specifically emphasize minimizing sedentary lifestyle, which is a universal modifiable risk factor for the occurrence and progression of cardiovascular and long-term metabolic diseases (hypertension, type 2 diabetes, and CKD). Chronic kidney disease (CKD) refers to the damage of the kidney with glomerular filtration rate (GFR) less than 60 mL/min/1.73 m² for at least three months (Chukwuonye et al., 2018)**.** Patients with CKD often experience physiological dysfunctions leading to muscular atrophy, which may be caused by the imbalance between synthesis and degradation of muscle protein, amino acid depletion, chronic inflammation, malnutrition syndrome, change in capillary profusion, peripheral neuropathy and physical inactivity (Tomich, Bernardino, Ferreira, 2014). Patients with CKD experience exercise intolerance-induced anemia and hypervolemia such that treatment of these conditions does not improve exercise tolerance (Kosmadakis et al., 2010). The exercise intolerance causes sedentary lifestyle, which leads to higher degeneration of physical and mental health (Hopman et al., 2009; Tomich et al., 2014). Based on this, physical activity is regarded an important factor in the primary treatment of CKD.

Numerous studies have shown that exercise is safe and beneficial for patients with non-dialysis (Kosmadakis et al., 2012; Gould, Graham-Brown, Watson, Viana, Smith, 2014; Sokunbi, 2017) and dialysis CKD (Johansen, 2008; Wilund et al., 2010). Despite these known benefits, patients with CKD involvement in PA is deficient. Supervised exercise programme is one of the components of health promotion intervention aimed to slow the progression of CKD, improve quality of life, reduce the need for hypertensive treatment, and morbidity and mortality (Segura-Ortí, 2010). PA has positive outcomes in exercise tolerance and reduction of inflammatory mediator. It increases the synthesis of muscle protein, reduce muscle protein degradation, and increase in the number and size of muscle fibers which increases the muscle strength. In addition, central gains such as improvement of left ventricular function, decrease in the occurrence of cardiac arrhythmias, reduced risk of cardiovascular and metabolic diseases have been reported (Hopman et al., 2009; Segura-Ortí, 2010; Nascimento, Coutinho, Silva, 2012; Sokunbi, 2017). As reported by Tomich et al. (2014), six weeks exercise intervention programme improved the functional capacity and the quality of life of patients living with CKD with the effect sizes ranging from moderate to large. Based on the numerous benefits of PA outlined above, it is imperative that health care practitioners treating patients with CKD (with other chronic lifestyle diseases) include PA in their treatment programme and encourage their patients to meet the recommended PA guidelines based on personalised intensities of PA.

Although, there are scanty statistics on the incidence and prevalence of CKD in Africa (and specifically in Nigeria), renal disorders especially glomerular disorders are more prevalent in Africa than in the western world (Naicker, 2003). The incidence of CKD accounts for 8–10% of hospital admissions in Nigeria which may be far from the true situation as the incidence of CKD is largely under recognized and underdiagnosed (Akinsola et al. in Ulasi, Ijoma, 2010). The cases of end-stage renal disease (ESRD) are mostly presented and it is believed that they represent the tip of the iceberg of the entire burden of CKD (Bello, Nwankwo, Nahas, 2005). The prevalence of CKD in Nigeria is about 26%, higher in females, and increase steadily with age (Alebiosu, Ayodele, 2005). The most common risk factors for CKD were obesity, diabetes mellitus, hypertension, family history of hypertension and family history of renal disease. The less common risk factors were low-income occupation, use of traditional

medications, low hemoglobin, and central obesity (Chukwuonye et al., 2018). The progression of CKD and its mortality is high and the major causes of death in this part of the world are late presentation and prohibitive cost of treatment, including indirect costs such as man hour loss at workplace or outright loss of job and its devastating consequence (Ulasi, Ijoma, 2010) especially, for those who are the bread winners of their families. Currently, the very few renal replacement therapies that are available are not readily accessible as most of these centres are situated in urban areas and are run with refurbished poorly maintained machines (Ulasi, Ijoma, 2010). Thus, PA becomes a vital alternative for slowing down the progression of CKD and its degenerative consequences since it is an easy, accessible, reliable and cost-effective resource for several health conditions.

The health care institution is suitable and promising for prescribing physical activity (Börjesson, 2013). Renal physicians have been advised to routinely assess patients' physical activeness and counsel sedentary patients to be physically active (Johansen, Sakkas, Doyle, Shubert, Dudley, 2003; Delgado, Johansen, 2010) but despite this recommendation, it is observed that the renal care team in Nigeria rarely address this issue in the care and management of patients. Based on the affective-reflective theory of physical inactivity and exercise (ART), it is assumed that a stimulus triggers automatic associations and a resulting automatic affective valuation of exercise (Brand, Cheval, 2019). Value or interest in exercising among CKD patients could be initiated and reinforced by the renal care practitioners. However, the practitioners' perceptions, experience, feelings, and thoughts about exercise influence is paramount and is often a reflection of their current exercise behaviour as only those who exercise routinely are most likely to encourage and support others to exercise. The health care professionals may fail to recommend exercise for their patients due to lack of consensus among transplant professionals about recommending and prescribing exercise, time constraints, lack of confidence in their ability to counsel patients, lack of conviction that patients will respond to counseling, and the belief that other medical issues are more important than exercise (Sokunbi, 2017). The assessment of exercise counselling habits amongst renal health care professionals in the USA (Delgado, Johansen, 2010), Canada (Ma, Lui, Brooks, Parsons, 2012), and in the UK (Greenwood et al., 2013) are available but to date, no formal evaluation of exercise counselling practices among renal care team has been conducted in Africa (including Nigeria).

The Nigerian Association of Nephrology (NAN) is a multidisciplinary body of renal experts in Nigeria, which was established in 1987. Members include renal physicians and other medical staffs (nurses, researchers, dietitian, physiotherapists, exercise scientists etc.) involved in the care of patients with kidney disorders or researching into renal medicine in Nigeria. The members meet annually for the Nigerian Association of Nephrology Conference (NANCONF). The present study was conducted during the NANCONF 2018 and the objectives were to (i) determine the perception of physical activity or exercise counselling and assessment, (ii) establish the physical activeness, and (iii) identify possible barriers to exercise counselling among the attendees.

Methods

A cross-sectional survey-designed study was conducted on renal multidisciplinary team (MDT) delegates that attended the 30th annual scientific conference and general meeting of the Nigerian Association of Nephrology Conference (NANCONF, 2018) in Ilorin, Kwara State, Nigeria.

Ethics

The study was reviewed and approved by Loughborough University's local ethics committee. The participants or respondents provided their written informed consent to participate in this study.

Participants

A short presentation of the study and the recruitment process was delivered during the plenary session (in a common room) to all the delegates. All the 403 renal practitioners who attended the NANCONF 2018 were recruited, however, only 281 (70.3%) validly participated in the survey. The participants' average age was 42 ±10 years, 53% females (n = 149) and 47% males (n = 132).

Data Collection

A questionnaire was adapted from Johansen et al. (2003), Delgado and Johansen (2010), and Greenwood et al. (2014). The questionnaire was validated by the steering committee of the Nigerian Association of Nephrology. It consisted of 24 items that were subdivided into four sections regarding opinions and practices related to exercise counselling. A 3-point Likert ratings of the opinions and practice (agree, disagree or do not know) and exercise counselling habits (frequently, infrequently or never), was used. Respondents were also asked how often they assessed patients' physical activity levels, prescribed or recommended physical activity, offered written information about physical activity, referred patients to exercise professional, or provided exercise equipment for patients' use during dialysis. They were then asked to choose from a list of barriers that hinder promotion of physical activity and exercise counselling practices in their hospitals. Information was collected about the characteristics of respondents' practices (practice settings and services available for patients with CKD). Finally, respondents indicated their levels of physical activity by choosing from a list of options based on the current physical activity guidelines and were asked to write other services or barriers not included in the survey (but available in their practice centres) in the free text box. The questionnaire required approximately 10 minutes to complete, was anonymous, and a designated member of the research team retrieved them instantly before the end of the conference.

Statistical Analysis

Descriptive statistical analysis was explored. The participants' characteristics were described using mean and standard deviation (SD), number (n), percentage (%) and bar charts for continuous and categorical variables. All the analyses were performed using IBM SPSS Statistics version 24.0 (Chicago, IL, USA).

Results

The distribution of respondents consisted of 50% nurses (n = 140), 39% nephrologists (n = 110; of which 25% were consultants) and 11% in other areas of specialization (n = 31). Their exercises practice (table 1) revealed low compliance to PA recommendation. Forty two percent (n = 119) of the respondents did not exercise regularly, 32% (n = 90) engaged in moderate intensity exercise for less than 5 days weekly. Twelve percent (n = 34) participated in moderate intensity exercise for more than 5 days per week, 7% (n = 20) engaged in vigorous intensity exercise on fewer than 3 days per week and 4% (n = 10) engaged in vigorous intensity exercise more than 3 days per week.

Table 1. Exercise Practice of Study Participants

Items	Response n = 281 (percentage)
How often do you engage in PA?	
1. Do not exercise regularly	119 (42)
2. Moderate <5 days/week	90 (32)
3. Moderate >5 days/week	34 (12)
4. Vigorous <3 days/week	20 (7)
5. Vigorous >3 days/week	10 (4)

Data are presented as n (%) unless otherwise indicated, PA, Physical Activity.

All the respondents reported that some type of PA/exercise service and human resources existed and were accessible in their units. As shown in figure 1, 53% reported that dietitians were the most available resource, 49% reported exercise professionals; only 19% reported having accessible exercise facilities in their dialysis centres. The large discrepancy suggests low attention is given to exercise as therapy for CKD patients.

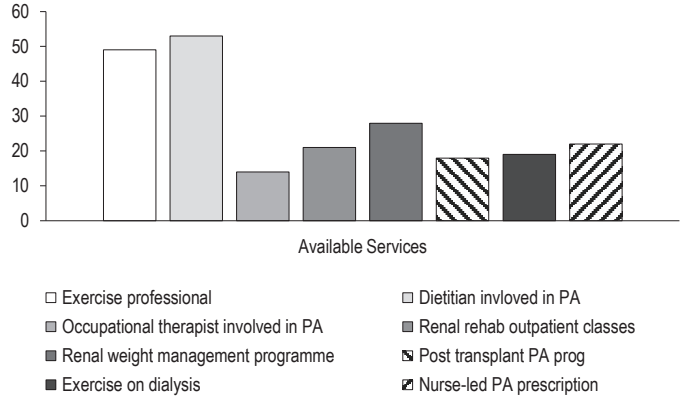

Figure 1. Distribution of currently available services for patients with CKD at various renal units (n = 281) (%)

Tables 2 and 3 presents responses to specific questions on the opinions and practices related to exercise counselling.

Table 2. Participants Responses (grouped by profession) to Opinion and Practice (%)

Opinion and Practice	Agree				Disagree				Do not know			
	Doctors	Nurse	Other	Overall	Doctors	Nurse	Other	Overall	Doctors	Nurse	Other	Overall
Physical inactivity is an important health risk in the general population	98	89	84	92	1	6	3	4	0	1	3	1
Increasing PA is beneficial for most people	99	95	87	96	0	2	3	1	0	0	3	0
PA is beneficial for patients with CKD	92	73	77	81	4	11	3	7	3	12	10	8
I am concerned about the risks of exercising in patients with CKD	46	50	52	48	44	40	16	38	7	7	19	8
I do not believe that patients with CKD would increase PA if advised to do so	16	39	42	30	75	49	32	57	6	8	19	9
I do not have time to talk to patients with CKD about PA during clinic visits	23	26	26	25	71	70	61	69	3	1	10	3
I do not think that patients with CKD are interested in the topic PA	18	30	36	26	68	61	42	62	10	6	16	9
I do not think that PA is an important part of patients with CKD therapeutic plan	5	19	13	13	86	70	61	75	6	6	23	8
I do not think that it is the role of the physician to counsel dialysis patients about PA	15	25	26	21	77	68	58	71	6	5	13	6
I do not feel confident in my ability to discuss PA with patients	18	17	13	17	77	78	61	75	2	4	19	5

For clarity, Doctors = Consultants, Senior Registrars and Registrars; Nurse = Renal Nurses; Other = other health professionals (physiotherapists, researchers, dietitians and others); PA, Physical Activity. Where responses for a question do not add up to 100% that is due to participant failure to answer the question.

Table 3. Participants Responses (grouped by profession) to Types of Exercise Counselling (%)

Exercise counselling	Frequently				Infrequently				Never			
	Doctors	Nurse	Other	Overall	Doctors	Nurse	Other	Overall	Doctors	Nurse	Other	Overall
I prescribe/recommend PA to patients	32	41	23	35	56	45	52	50	10	12	13	11
I provide may patients with written information	4	22	16	14	48	40	36	42	46	35	29	39
I refer my patients to exercise professional	9	21	26	17	36	32	26	33	51	43	29	45
I facilitate the provision of equipment for PA on dialysis	3	16	16	11	18	23	16	20	76	56	42	63

For clarity, Doctors = Consultants, Senior Registrars, Registrars; Nurse = Renal Nurses; Other = other health professionals (physiotherapists, researchers, dietitians and others); PA, Physical Activity. Where responses for a question do not add up to 100% that is due to participant failure to answer the question.

The themes of barrier that could hinder the promotion/provision of PA facilities (Figure 2) indicates that 75% of the respondents reported lack of motivated patients due to poor health or lack of awareness, 69% of the respondents reported lack of resources (dialysis bed, exercise equipment) or difficulty with the existing ones, 66% of the respondents reported lack of money or funding, 63% of the respondents reported lack of motivated staff, 57% of the respondents reported lack of qualified personnel, and 32% of the respondents reported cultural or religious beliefs as barriers.

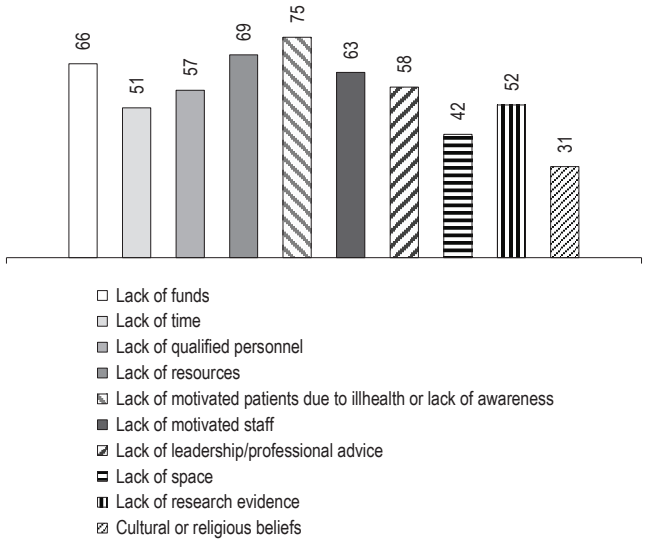

Figure 2. Reported barriers to PA

Discussion

The present study is the first to examine varying patterns and attitudes towards exercise counselling habits and identifying the barriers that may hinder exercise counselling amongst renal care team in Nigeria. The examined wider renal care team involved in the management of patients across all stages of CKD differed from previous studies that focused on renal physicians only (Delgado, Johansen, 2010; Johansen et al., 2003) or haemodialysis staff (renal nurses, dietitian, technician and administrators) (Capitanini et al., 2014). Most respondents acknowledged the importance of an active lifestyle for health, yet very few provided specific recommendations or referrals to facilitate exercise participation for their patients.

Although 42% of respondents were inactive and 12% engaged in moderate exercises for more than 5 days weekly, 92% of the overall respondents admitted that physical inactivity is an important risk to health of the general population; 96% and 81% acknowledged that increasing PA is beneficial for most people and the CKD population (Table 2). One would assume that the views and beliefs of our respondents about the benefits of physical activity would reflect in their habit but that was not so as the present study indicated a very low percentage of active participants (12% of the respondents). Also, their opinions about the health risks of a sedentary lifestyle and the benefits of PA did not correspond with their own level of PA. Of the 75% of the respondents that agreed that PA is an important part of patients' therapeutic plan and are confident to discuss PA with patients, only 35% of them routinely prescribed and recommended PA to their patients.

Seventy-one percent of the respondents believed that it is the role of the physicians to counsel patients about PA, however, actual recommendations were made by just 11% of respondents who routinely facilitate the provision of equipment for PA to patients on dialysis, 17% referred patients to exercise professionals, and 14% provided patients with written information about physical activity (Table 2). The above findings are comparable to the study

of Greenwood et al. (2014); a similar study that was conducted in the UK. Their results revealed that 42% of the overall respondents discussed and encouraged PA, but only 11% of respondents facilitated implementation of PA for their patients. From these, the beliefs and opinions about the benefits of physical activity by renal care team members in Nigeria are not translated into meaningful habitual physical activity that would facilitate behaviour change for long term health benefits of patients. To support this, 19% of the respondents have existing facilities for exercise during dialysis in their centres, 21% reported current nurse-led physical activity prescription, 53% reported available dietitian involved in physical activity, and 49% reported existing exercise professionals in their centres. Half of the respondents were nurses (50%), a pointer to high distribution of nursing staff compared to other renal health professionals (doctors, physiotherapists, dietitians). The availability of experts such as nurse-led PA specialist and occupational therapist involved in PA is also necessary for longer-term sustainability of counselling habits.

Although most of the respondents recognised the importance of increasing PA, they do not actively promote PA in the care and management of their patients. We identified several existing barriers to exercise counselling among renal care team in Nigeria. The commonest reported barrier was lack of motivated patients due to ill health or lack of awareness (75% of respondents). Measures to educate patients about their disease and the benefits of habitual PA in addition to addressing factors that could prevent widespread implementation of patient education could result to better patient outcomes. The present study also reported lack of resources (69% of respondents) and lack of funding (66% of respondents) as important barriers to exercise rehabilitation of CKD patients in Nigeria. Other potential barriers were lack of motivated staff (63% of respondents), lack of leadership or professional advice (58% of respondents), lack of qualified personnel (57% of respondents), and lack of time (51% of respondents). Therefore, these barriers could have accounted for the low referral of patients to exercise professional and the low facilitation of provision of equipment during dialysis. Similar themes reported in the present study also emerged in the studies of Greenwood et al. (2014), Ma et al. (2012), and Delgado and Johansen (2010). In addition, lack of space (42% of respondents), lack of research evidence (52% of respondents), and cultural and religious beliefs (31% of respondents) were also reported as barriers to effective exercise counselling habits for CKD patients in Nigeria. In addition to factors identified in other countries, there are also challenges specific to the economic, social and cultural situation in Nigeria.

Haemodialysis is the commonest modality of renal replacement therapy in sub-Saharan Africa (Oluyombo et al., 2014) and Nigeria remains the most populous country in Africa and the seventh globally with an estimated population of over 198 million (Adeyemo, 2018). About 70% of the population live on below $1.50 per day and just 5.6% of the country's budget is spent on health care (Human Development Report, 2014). The country has the third highest number of patients on haemodialysis after Kenya and South Africa (Pozo et al., 2012). Recently, the establishment of dialysis centres owned by private companies and the government have been increasing, but these facilities are densely situated in the urban areas that are inaccessible to most CKD patients, low sustainability of dialysis due to poor maintenance of the dialysis machines (Oluyombo et al., 2014). Therefore, these drawbacks need to be addressed for an effective provision and implementation of exercise services for patients living with CKD in Nigeria.

The limitations of this study include involving only delegates that attended the NANCONF annual meeting, which may not be a representation of the entire renal care team members in Nigeria. The respondents from the host centre, University of Ilorin Teaching Hospital, outweighed respondents from other centres in Nigeria. We also observed that there was a larger response rate from nurses possibly due to their distribution in the sample size

compared to other renal care team and knowing that nephrologists remain the primary care providers of CKD patients (Delgado, Johansen, 2010), may have biased the results. Furthermore, respondents from centres where exercise-related rehabilitation services are being practiced may have a wider knowledge and understanding of the potential benefits of exercise in CKD management and could perhaps more likely, counsel patients about PA. Therefore, our findings should not be generalised on the entire renal team in Nigeria but considered as a guide to future investigation.

Conclusions

The results of this study demonstrated that renal care professionals established the importance of PA as a therapeutic option for health of CKD patients however, practical referral and guidance were poorly practiced. The lack of motivated patients, resources, funds, motivated staff, qualified personnel and research are the common barriers that renal care team in Nigeria face in the implementation of PA among CKD patients. Based on the principle of "practice what you preach", and given that healthcare professionals are the main sources of preventive care information to the public, a better understanding of the relationship between renal care teams' PA behaviour and their counselling habit is required to guide the development of interventional studies aimed to promote active lifestyles amongst renal care teams. This might further improve the health of CKD patients. Therefore, measures to address the reported themes of barriers with the provision of accessible and affordable renal replacement therapy, and the sustainability of such facilities would go a long way in reducing the burden of the late presentation of the disease (end stage renal disease).

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POSSIBILITIES OF USING OUTPATIENT PHYSIOTHERAPY IN THE PROCESS OF REHABILITATION OF PEOPLE WITH DEGENERATIVE DISC DISEASE IN THE LUMBOSACRAL SPINE

Bartosz Bolach[A, E, C]

Faculty of Physical Education and Sport, Department of Paralympic Sports, Academy of Physical Education in Wroclaw, Poland
ORCID: 0000-0002-3433-4434

Jagoda Walowska[B, D]

RB Dr Jagoda Walowska, Wroclaw, Poland
ORCID: 0000-0002-0130-0211 | E-mail: jagodawalowska@wp.pl

Paulina Chabraszewska[A, B, C]

Institute of Physiotherapy, University of Physiotherapy in Wroclaw, Poland

Karina Ryterska[D]

Pomeranian Medical University in Szczecin, Poland
ORCID: 0000-0003-2791-3312

Eugeniusz Bolach[D, E]

Faculty of Physical Education and Sport, Department of Paralympic Sports, Academy of Physical Education in Wroclaw , Poland
ORCID: 0000-0003-1857-0522

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Founds Collection

Abstract Degenerative disc disease (DDD) in the lumbosacral spine is one of the most common causes of pain and the significant associated limitations in physical activity and daily functioning, with the vast majority of patients requiring long-term physiotherapy. Hence, the significance of proper diagnostics, locating the cause of the ailment, implementation of appropriate therapy and prevention.

The aim of the study was to investigate the efficacy of outpatient physiotherapy on reducing pain and improving the function of the lumbosacral spine. The research group comprised 95 people (50 women and 45 men) with an average age of 53 years, all patients with DDD in the lumbosacral spine. They underwent 3 physical treatments: magnetotherapy, laser therapy, and systemic cryotherapy, as well as gymnastic exercises, aimed at improving physical fitness, and strengthening the muscular corset. The research methods included the Schober test, the Thomayer test (finger-ground test), the Visual Analogue Scale scale, Laitinen's pain questionnaire, and calculation of BMI.

Physiotherapeutic treatments significantly reduced the patients' pain symptoms, significantly increased the range of motion in the lumbosacral spine and improved physical fitness. Better results of the therapy were observed in patients with lower BMI.

Key words intervertebral disc, fibrous annulus, nucleus pulposus, spine

Introduction

Degenerative disc disease (DDD) in the lumbosacral spine is one of the most common causes of pain and significant associated limitations in physical activity and everyday functioning. It is estimated that this condition affects 12–35% of the human population. The lumbosacral spine is particularly vulnerable to injuries and can overload as a result of everyday activities. The intervertebral disc can be damaged, resulting in displacement of the pulmonary nucleus, along with irritation of other anatomical structures located within the lesion, such as joint capsule, interspinal and longitudinal ligaments, paraspinal muscles, nerve root sheaths, dura mater, vertebral body, and connective tissue in the area of the lesion within nerves and blood vessels. However, only a small percentage of patients require surgery. The vast majority qualify for conservative treatment aimed at reducing both the pain and the negative consequences to physical fitness (Colombini, Lombardi, Corsi, Banfi, 2008; Roughley, 2004; Frost, Camarero-Espinosa, Foster, 2019). When long-term pain contributes to the occurrence of chronic discomfort in the sacral spine and the entire back, treatment and therapy require more time and increased economic outlays (Hodgkinson, Shen, Diwan, Hoyland, Richardson, 2019).

Many factors can affect the integrity of the intervertebral disc. These include mechanical and genetic factors, past injuries, and diet. Progressive degenerative processes include structural damage to the intervertebral disc and changes in cell number and composition. A major factor in the degeneration of the intervertebral disc is the loss of proteoglycans. Degenerative changes in the disc are also associated with damage to adjacent structures which lead to functional changes, such as increased susceptibility to injuries and increased clinical symptoms (Kos, Gradisnik, Velnar, 2019).

There is a correlation between the location of the occurrence of back pain and age, sex and changes observed in the MRI scan. Male intervertebral discs degenerate more than women in the second, third, fourth, and even seventh decades of life. The most common degenerative changes concern the vertebrae L4–S1. Additional predisposing factors include a sedentary lifestyle, smoking and obesity (Cheung at al., 2009; Kanayama, Togawa, Takahashi, Terai, Hashimoto, 2009; Miller, Schmatz, Schultz, 1988; Like at al., 2005). Due to the nature and extent of the changes, as well as the prolonged pain which significantly limits the ability to function freely, these patients sometimes require long-term leave from work and rehabilitation, one of the main assumptions of which is to minimize pain and improve functioning in everyday life Peolsson at al., 2014; Newell et al., 2017). The vast majority of patients require long-term physical therapy. That is why proper diagnostics, locating the cause of the ailment, and implementing appropriate therapy and prevention are so important (Urban, Roberts, 2003).

Aim of the study

The aim of the study was to investigate the efficacy of outpatient physiotherapy on reducing pain and improving spine function in patients with DDD in the lumbosacral spine.

Research questions

1. To what extent did the mobility of the lumbosacral spine improve after outpatient rehabilitation?
2. Is the feeling of pain after outpatient rehabilitation different between sexes?

Material

The research was conducted at the "CREATOR" Non-Public Healthcare Center in Wrocław. 50 women and 45 men, aged 46 to 60 years, were examined. The age distribution of the men and women was very similar. The mean age of the women was 53.7 years with a standard deviation of 4.2 years, while the mean age of the men was 53.5 years with a standard deviation of 4.7 years. The average weight of the women was 68.8 kg, and the men 91.4 kg. Importantly, the mean BMI values of the women and men were within the range of overweight. The difference in the BMI distributions of women and men was statistically significant. Women were characterized by a higher level of education than the men. They also performed office work more often.

Methods

The orthopedic doctor selected 95 people diagnosed with pain due to DDD. Each patient before and after the rehabilitation cycle was examined using the Schober test and Thomayer test (finger-ground test), and the level of pain perception was assessed. Results were processed using the Visual Analogue Scale (VAS) and the Laitinen's Pain Questionnaire.

The scope of the outpatient physiotherapy used included 20-minute magnetotherapy treatment at a frequency from 0 Hz to 50 Hz and a field of 6 mT to 10 mT, trigger point laser therapy (1 cm^2) with a dose of 6–9 J/cm^2, systemic cryotherapy in a cryochamber (from –60°C to –130°C). The clinical therapy procedures were followed by classes in systemic gymnastics aimed at reducing back pain and strengthening the postural muscles responsible for the correct body posture and stabilization of the thoracic-lumbar spine. The gymnastics began with a 10-minute warm-up on a cyclo-ergometer, then the patients participated in a 20-minute group gymnastic exercise comprising 14 flexion exercises.

The set of exercises

1. Lying on the back, upper limbs along the body, lower legs straight. Exercise: alternate bending of the lower limbs by grasping the knee joint and pulling it towards the chest while lifting the head.
2. Item as above. Exercise for bilateral bending of the lower limbs by grasping both knee joints and pulling them to the chest while raising the head at the same time.
3. In the supine position, upper limbs downwards obliquely, lower limbs bent at an angle of about 60 degrees. Exercise for alternating sideways twisting of both lower limbs.
4. In the supine position, the upper limbs along the body, the lower limbs bent at an angle of about 60 degrees. Exercise to lift the torso up and down.
5. Lying on the back, upper limbs along the body, lower legs straight. Exercise for bending the upper and lower limbs with a simultaneous deep inhalation through the nose and extension of the limbs with a simultaneous longer exhalation.
6. In the front lying position, chin rested on a mattress, upper limbs along the body, lower legs straightened. Exercise of alternating lower limb lifting.
7. In the front lying position, chin rested on the mattress, upper limbs up, lower legs straight. Exercise of alternating lifting of the upper left and lower limb right and upper right and lower left limb.

8. In the front lying position, chin resting on the mattress, upper limbs up, lower legs straightened. Exercise for simultaneous lifting of upper and lower limbs. Kneeling, propped up. Exercise of alternating lower limb lifting.

9. Kneeling, propped up. Exercise of alternating lifting of the upper left and lower limb right and upper right and lower left limb.

10. Slow kneeling, the arms along the body. Exercise for lifting the upper limbs while inhaling deeply through the nose and lowering them downward while exhaling for a longer time.

11. Free kneeling. Left torso twist exercise, while grasping the left hand for the left heel and the right hand for the right heel.

12. One-legged slow kneeling, the other lower limb straightened at the knee joint. Exercise of lifting both upper limbs and bending the torso to the straightened lower limb and returning to the starting position, and then changing the position of the limbs.

13. In a standing position, lifting the upper limbs, inhaling through the nose and exhaling through the mouth. Each exercise was performed for 10 repetitions. Patients tried to perform 3 series of exercises, of which breathing exercises were performed up to 6 repetitions.

Statistical analysis

In the statistical description of the research material, mean values, standard deviations and the range of variability of the feature were used. The statistical significance of changes in the examined features from the performed physiotherapeutic procedures was assessed using the Student's t-test for dependent samples. While the null hypothesis about the lack of influence of physiotherapy on the distribution of the analyzed trait being true, the Student t-distribution with N – 1 degrees of freedom was true, on the basis of which the significance level p was determined. Sexual dimorphism of the analyzed traits was tested using the Student's t-test for independent samples. If the null hypothesis about the lack of sex-related differentiation of the distributions of the analyzed feature was true, we tested the t-Student's distribution with N1 + N2 – 2 degrees of freedom. The relationship between the distribution of BMI values and gender was assessed using the chi square (χ^2) test of independence. Taking into account the division of BMI values into three categories and the validity of the null hypothesis about the lack of a relationship between sex and BMI distribution, the χ^2 test function had a Pearson chi-square distribution with two degrees of freedom. When verifying the null hypotheses, a critical significance level $\alpha = 0.05$ was used. The calculations were performed using STATISTICA v.10 package by StatSoft (Shapiro, Wilk, 1965; Siegel, 1956).

Results

In the Schober test, all patients obtained better results after using outpatient physiotherapy. Before the start of the treatment cycle, the total percentage of people, regardless of gender, with the correct result (i.e. 5–7 cm) in the entire study group was 20.5% (women 28% and men 13%), which almost doubled after physiotherapy at 38.5% (50% for women, 27% for men). The mean Schober test results in the group of men were worse than in the group of women, both in the initial study and after physiotherapy. The difference in mean results in both sex groups was at the borderline of statistical significance in the initial study ($p = 0.06 \approx 0.05$), and after the applied physiotherapy it was statistically significant.

When analyzing the Thomayer test, it was noticed that in the initial study, before the start of the cycle of physiotherapeutic treatments, men achieved significantly worse results than women. The difference in mean

results could not be considered statistically significant at the adopted level of significance ($p = 0.073 > 0.050$), but p was close to the critical value of $\alpha = 0.05$. The result of the Thomayer test correlated significantly with the BMI value. The rank coefficient of Spearman's BMI and the result of this test in the initial study was $\rho = –0.42$. The correlation was negative, which meant that higher BMI values were not conducive to achieving good results in this test. Therefore, the worse results of men were a consequence of higher BMI values compared to those achieved by the women. Also after physiotherapy, the mean score of men was still lower than the mean score of women, but the difference in mean values in both groups lessened. The improvement of the Thomayer test result after outpatient physiotherapy was strongly negatively correlated with the test result obtained before the start of the treatment cycle. The Spearman's rank correlation coefficient was in this case $\rho = –0.76$. This explains why the improvement was greater in the group of men. The negative correlation indicated that greater improvement should be expected in people who had worse results in the Thomayer test before the therapy, and such people were mainly men.

Analyzing the pain scale, it was found that the applied forms and types of therapeutic rehabilitation contributed to a reduction in the subjective level of experiencing pain. The mean value of pain intensity was significantly higher in the group of men, both in the initial and final study. The applied outpatient physiotherapy decreased the mean value of pain by more than 4 points on the VAS scale. This change was highly statistically significant. The mean pain reduction was virtually independent of gender. In the group of women, the mean change in the intensity of perceived pain was 4.12 on the VAS scale, and in the group of men it was 4.22.

Table 1. Comparison of the results achieved in tests and scales in the group of women and men before and after outpatient physiotherapy

Test	Sex	$\bar{x}$	Dev. Std.	Minimum	Maximum	Student test	
						t	p
Schober test [cm]							
Before physiotherapy	women	3.43	1.54	1.0	7.0	1.90	0.061
	men	2.89	1.21	1.0	5.0		
After physiotherapy	women	4.45	1.29	2.0	7.0	2.53	0.013
	men	3.79	1.25	1.0	6.0		
Toe-to-floor test [cm]							
Before physiotherapy	women	-9.9	13.0	-60	15	1.82	0.073
	men	–14.4	10.8	-46	3		
After physiotherapy	women	–4.1	8.7	-35	15	1.55	0.126
	men	–7.0	9.5	-39	8		
Pain on the VAS scale [pts]							
Before physiotherapy	women	6.80	1.60	3.0	10.0	2.87	0.005
	men	7.78	1.72	4.0	10.0		
After physiotherapy	women	2.68	1.73	0.0	7.0	2.62	0.010
	men	3.56	1.50	0.0	7.0		
Laitinen pain questionnaire [pts]							
Before physiotherapy	women	6.7	1.9	4.0	12.0	3.49	0.001
	men	8.2	2.1	4.0	13.0		
After physiotherapy	women	2.5	1.8	0.0	8.0	3.25	0.002
	men	3.7	1.9	1.0	8.0		

The performed physiotherapeutic procedures reduced the level of perceived pain, as assessed with the Laitinen pain questionnaire. The observed changes were highly statistically significant. The mean reduction in pain experienced was only slightly greater in the male group. The effects of the performed physiotherapy in terms of the reduction of pain intensity on the VAS scale as well as the reduction of pain perception on the Laitinen scale were similar. The rank correlation coefficient for both these features was $\rho = 0.60$ and was statistically highly significant ($p < 0.0001$). The Laitinen questionnaire assessed not only the intensity and frequency of pain, but also the physical limitations caused by the pain and the number of pharmaceuticals used. Table 1 compares the results achieved in individual tests and scales, in both the groups of women and men, before starting outpatient physiotherapy and after completing the 10-day cycle of physiotherapy. Table 2 shows the average changes in the results achieved in the individual groups of the studied women and men.

Table 2. The average change in test results and the feeling of pain before and after outpatient physiotherapy

Test/scale	Sex	Before physiotherapy		After physiotherapy		Average change	Student test	
		$\bar{x}$	SD	$\bar{x}$	SD		t	P
Schober test [cm]	women	3.43	1.54	4.45	1.29	1.02	13.75	<0.0001
	men	2.89	1.21	3.79	1.25	0.90	17.40	<0.0001
	both sexes	3.17	1.41	4.14	1.31	0.96	20.81	<0.0001
Thomayer test [cm]	women	–9.90	13.00	–4.10	8.70	5.80	7.62	<0.0001
	men	–14.40	10.80	–7.00	9.50	7.40	16.49	<0.0001
	both sexes	–12.00	12.20	–5.40	9.10	6.60	14.30	<0.0001
Pain on the VAS scale [pts]	women	6.80	1.60	2.68	1.73	4.12	24.86	<0.0001
	men	7.78	1.72	3.56	1.50	4.22	21.30	<0.0001
	both sexes	7.26	1.72	3.09	1.68	4.17	32.68	<0.0001
Laitinen pain questionnaire [pts]	women	6.72	1.88	2.50	1.82	4.22	28.27	<0.0001
	men	8.16	2.12	3.73	1.88	4.42	21.87	<0.0001
	both sexes	7.40	2.12	3.08	1.94	4.32	34.90	<0.0001

Discussion

The aging of the populations in the West and elsewhere has been associated with a proportional increase in the incidence of conditions of the intervertebral disc. These conditions are the main cause of back pain limiting to a large extent everyday functioning. That is why it is so important to conduct an accurate diagnosis, which is of key importance for further treatment.

A thorough understanding of the pathophysiology and clinical symptoms helps in recognizing and locating the cause of these conditions. There is extensive literature on the treatment of intervertebral disc conditions. Most often, we treat this ailment by focusing on relieving pain through the use of conservative treatment. Other methods are surgical treatment and the use of molecular therapy, injections in lesions, or the use of stem cell treatment (Wu, Kim, Jang, 2020; Barakat, Elwell, Lam, 2019). In a review of 41 research studies on a total of 6,858 patients, Kamper et al. (2015) showed that sixteen of them provided moderate-quality evidence that multidisciplinary rehabilitation reduced pain (standardized mean difference 0.21–95% confidence interval 0.04 to 0.37; equivalent to 0.5 point on a 10 point pain scale) and disability as a consequence of these conditions (0.23, 0.06 to 0.40; equivalent to 1.5 points on a Roland-Morris 24-point index), compared to usual care not involving physiotherapy. Eight studies

provided moderate-quality evidence that multidisciplinary rehabilitation increases job prospects one year after the intervention (odds ratio 1.87–95% confidence interval 1.39–2.53). Two studies comparing multidisciplinary rehabilitation with surgery found a slight difference in outcomes and an increased risk of side effects associated with surgery. This means that properly planned and carried out rehabilitation is extremely important in the rehabilitation process in people with degenerative disc disease (DDD).

Treatments should be performed systematically and appropriately selected according to the ailment and its cause (Kamper at al., 2015). As early as in the 1980s, Zylbergold and Piper (1981) showed in their monthly studies that both the use of exercises aimed at ailments related to the lumbar spine, as well as manual therapy procedures, systematic home visits and patients exercising at home, are effective in the treatment of DDD. Adamczyk, Kiebzak, Wilk-Frańczuk, Śliwiński (2009) compared the results of two different physiotherapeutic approaches in the treatment of back pain in 60 patients. In the study group, an individual treatment program was applied, including post-isometric muscle relaxation (PIR), Kibler Fold spine mobilization, Kinesiology Taping and relaxation exercises. The control group, on the other hand, underwent electrotherapy and performed a set of general development exercises. Pain intensity and difficulty in carrying out daily activities were assessed at the beginning and end of treatment. The measurements included spine mobility, static balance, muscle and ligament tenderness and tension, and the identification of areas with pain ailments. As a result of the intervention, a significant reduction in back pain was found (90% of patients in the study group), and in (80% of patients) balance, muscle and ligament tension, and spine mobility improved. In the control group, radiating pain decreased by (25%), and the remaining parameters did not change significantly. The results were statistically significant at $p < 0.05$. The authors of this publication, and also Fronczyk and Kuliński (2017), came to the conclusion that physiotherapy is the basis for rehabilitation of patients with back pain syndromes. Fronczyk and Kuliński (2017) analyzed the possibility of using physiotherapy in patients with lumbosacral DDD. The study included a group of 54 patients aged 20–60 years. The research tool was a questionnaire prepared by the authors. The questionnaire included 17 closed and 5 open questions. The results were assessed using two subjective pain intensity scales: the VAS scale and the Laitinen pain index. Moreover, the Schober symptom was used to assess lumbosacral mobility. The conducted research showed that rehabilitation performed in patients reduced pain and improved spine mobility, they took painkillers less frequently and could undertake more frequent and more intense physical activity. Krawczyk-Suszek, Szlichta-Kołeczek, Bednarski (2018) emphasized that the concept of DDD in the lumbosacral spine encompasses all pathological changes within the intervertebral disc which cause characteristic clinical symptoms, mainly pain in the lower part of the spine, often radiating to the lower limbs, and also tingling, numbness and limited mobility of the torso. Their study included 140 people diagnosed with DDD. The research method was a proprietary questionnaire supplemented with the VAS scale. The tests were performed before and after rehabilitation. The data was analyzed statistically. Among the treatments used in patients, exercises aimed at strengthening the lumbar spine and abdominal muscles dominated. In addition, therapeutic massage, TENS currents and manual therapy were used. The mean pain intensity before rehabilitation was 7.21 points ±1.54 points, while after rehabilitation = 3.44 points ±1.97 points ($p < 0.001$). Outpatient physiotherapy reduced the pain and contributed significantly to the improvement of the patients' quality of life.

In a study in Hungary, one of the non-invasive methods used to reduce pain in the lumbar spine was traction under controlled conditions. The therapy focused on an attempt to position the spine in the correct position while maintaining the curvature of the spine, which was to affect the reposition of the incorrectly positioned intervertebral disc. It should be emphasized that it was not a universal form of therapy that can be performed in every patient.

Physical exercise and physical activity undertaken by patients with DDD is extremely important, but as França, Burke, Hanada, Marques (2010) emphasize, better results are achieved by people who perform targeted exercises to strengthen the deep muscles and stabilize the lumbar spine. Performing exercise of a systemic nature has a global impact, contributing to a reduction in pain, moreover, the therapeutic effect is shorter. This study and the research by Plaskiewicz, Kałużny, Kochański (2015) reached similar conclusions, and extended the rehabilitation program additionally with physical therapy. They found that the use of physiotherapeutic procedures, including cryotherapy, electrotherapy, laser therapy, magnetotherapy, ultrasound and heat therapy are particularly effective in the treatment of DDD.

Regardless of the cause and course of DDD, particular attention should be paid to prophylaxis and lifestyle changes related primarily to a significant reduction in the sitting position during the day (Kwon at al., 2018). The positioning of the lumbosacral spine is a key factor for the proper functioning of the spine. Changes in the position of the spine lead to disturbances in the biomechanics of the body and gait. This affects the quality of life, body balance and increases the risk of falls in the elderly (Kocyigit, Berk, 2018). Back pain patients show a variety of kinetic changes when walking on flat ground and when climbing stairs. Both adaptation strategies put additional strain on the spine and joints and additionally increase the risk of developing disc conditions. Kuai et al. (2017) in the gait analysis laboratory compared the gaits of people with pain and in healthy adults. They found that patients with DDD showed significant compensation when performing movements and higher activity of the trunk muscles both when walking on flat ground and climbing stairs. There was a decrease in the anterior-posterior shear forces acting on the discs in the pathological area and an increase in compressive forces on all lumbar vertebrae when walking on flat ground. When climbing stairs, shear forces dominated, which is why, among others, Azadinia, Ebrahimi-Takamjani, Kamyab, Parnianpour, Asgari (2017) conducted long-term research on the type of physiotherapeutic intervention and its impact on body posture and the way of moving. Pain located in the lumbar spine is one of the most frequently diagnosed condition entities and one of the most frequently reported ailments and the cause of the inability to work. The causes of non-specific pain syndromes are myofascial overloads, ligament injuries, and psychogenic factors. Most often, the cause of the ailment is difficult to pinpoint. In turn, specific pain syndromes are most often caused by hernia of the nucleus pulposus, spondylolisthesis, stenosis of the spinal canal, degenerative changes in the inter-process joints, vertebral fractures, spine tumors or inflammatory diseases. Pain may be perceived as dull, diffuse, with a burning or stinging sensation. They can also cause radiating pain. DDD and related pain syndromes generate huge financial costs, including those for the state budget. They require long-term diagnostics, treatment and rehabilitation, which is associated with the payment of unemployment benefits and pensions. Therefore, the cooperation of the entire therapeutic team is recommended in order to diagnose as soon as possible and obtain positive treatment results (Manek, McGregor, 2005; Rubin, 2007).

Conclusions

1. In the Schober phenomenon, the subjects showed an improvement in the mobility of the lumbosacral spine in both groups. Women achieved statistically better results.
2. In the Thomayer test, there was a negative correlation with BMI values, which resulted in better results for men.
3. The 10-day therapy significantly increased the range of mobility of the lumbosacral spine in all the patients studied.

4. Physiotherapeutic procedures significantly reduced the patients' pain symptoms by an average of more than 4 points on the VAS scale. The mean pain reduction was not biased by gender.

5. According to the Laitinen questionnaire, the values of perceived pain were higher in men both in the initial examination and after the application of physiotherapy.

6. Physical limitations caused by pain and the number of painkillers used have reduced significantly after physiotherapy.

7. Better results of the therapy were observed in patients with lower BMI values.

8. Men showed higher values of BMI. In a group where there was not a single subject with a normal body mass BMI, as opposed to 14 subjects.

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LEVEL OF PHYSICAL ACTIVITY AMONG PERSONS FROM INDEPENDENT CULTURAL CENTERS ACCORDING TO THE IPAQ CLASSIFICATION

Michał Bergier[A,B,C,D]

Pope John Paul II State School of Higher Education in Biala Podlaska, Poland
ORCID: 0000-0003-3407-1504 | e-mail: michalbergier@gmail.com

Barbara Bergier[D]

Pope John Paul II State School of Higher Education in Biala Podlaska, Poland
ORCID: 0000-0002-9268-4942 | e-mail:barbara.bergier@wp.pl

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Abstract In times of prevailing civilization diseases physical activity has become not only a vital element of a healthy lifestyle but also a duty of every human being. Subsequently published studies present the levels of physical activity in various socio-professional groups and the degree to which they meet health promotion recommendations. The challenge of today's times however is the search for new, often atypical or niche social groups and their efforts in undertaking and promoting physical activity. Such a type of group undoubtedly includes persons in the Independent Cultural Centers (ICCs) operating in Poland. The research conducted among them is probably the first attempt to get to know this social group and, above all, the physical activity undertaken by its members. Accordingly, the following work presents the level of physical activity of people from ICCs using, as a research method, the International Physical Activity Questionnaire (IPAQ) in its short version.
Despite the fact that the activities of Independent Cultural Centers are organized in a bottom-up manner, in accordance with the Do It Yourself principle, their initiatives, including those related to physical culture, enable participants to achieve beneficial health outcomes. The results of the conducted research show that, following the International Physical Activity Questionnaire (IPAQ) criteria, a vast majority of the respondents are sufficiently and highly active. Only 3.8% of the respondents showed an insufficient level of physical activity according to the IPAQ criteria. Moreover, compared to similar groups in other respects, they also come out more favorably.

Key words physical activity, Independent Cultural Centers, IPAQ

Introduction

Non-communicable diseases (NCDs) are currently a major threat to human health. It is estimated that preventive measures could significantly reduce premature deaths caused by NCDs, even by 80 percent (Abdellatif, Souad, 2020; Malhamé, Pilote, Destiné, Israel, Oettingen, 2019; Geidl, Abu-Omar, Weege, Messing, Pfeifer, 2020; Sarmento et al., 2020; Salman, Tolma, Chun, Sigodo, Al-Hunayan, 2020). Accordingly, regular physical activity, referred to as a pro-health factor, plays a key role in human life (Malm, Jakobsson, Isaksson, 2019; Warburton,

Bredin, 2019; Vert et al., 2019). The significance of physical activity in the context of health has been emphasized for many years by the World Health Organization (WHO), which claims that our health is determined by lifestyle and related to it physical activity in 50% (Bergier, 2012). As the authors of numerous research studies emphasise, the lack of physical activity is the main cause of many diseases and deaths (Rector, Thyfault, 2011; Jodkowska, Tabak, Oblacińska, Stelmach, 2013, Kruk, 2014). Therefore, the fight against a sedentary lifestyle and the promotion of physical activity are becoming a key element in health prevention policies (White, Pettee, Yongin, Lewis, Sternfeld, , 2015, Turner, Avolio, 2016, Shephard, 2017).

Much research conducted in Poland concerned physical activity of various social and occupational groups (Madejski et al., 2018; Kubińska, Pańczuk, 2019; Chuchra. Gorbaniuk, 2019; Domagała, 2019; Biernat, 2011), including elderly persons (Włodarek et al., 2012), teachers (Soroka et al., 2017), administration employees (Biernat, 2011), management staff (Nawrocka, Prończuk, Mynarski, Garbaciak, 2012), prison employees (Wojciechowski, Bergier, 2016), those in confinement (arrested and sentenced) (Kosendiak, Trzeciak, 2019) or students (Niźnikowska et al., 2019; Gajda, 2020). All these studies used both the short and long versions of the International Physical Activity Questionnaire (IPAQ). The tool allows for testing various types of efforts undertaken over subsequent 7 days and lasting nonstop for at least 10 minutes.

The huge role attributed to physical activity in health prevention poses a challenge related to the study of physical activity in new, previously unresearched social groups. The following paper aims at presenting the results of the study on physical activity in the so far untested group, i.e. persons from operating in Poland Independent Cultural Centers. Their activity often involves grass-roots initiatives in which young people undertake various types of social and cultural enterprises, including those related to physical activity (Yoga, martial arts, strength and endurance training, cycling events). The presented results concern people from four such centers located in Lublin, Wrocław, Gliwice and Warsaw.

Research material and methods

The study involved 112 persons, 104 of whom submitted correctly completed questionnaires. The latter number of the respondents was taken into account in the statistical analyses. The average height of the subjects was 177.3 cm (SD = 9.8), including 167 cm (SD = 5.3) in women and 183.2 cm (SD = 6.2) in men. The respondents' body weight was on average 69.9 kg (SD = 12.6) in women – 54.6 kg (SD = 5.1) and 78.7 kg (SD = 4.6) in men.

The study group consisted of 38 women and 66 men aged 19 to 46 and the research covered all active Independent Cultural Centers in Poland including:

- the Association for the Reanimation of Alternative Culture based in Wrocław, at Jagiellończyka 10 c/d;
- the *Krzyk* Ecological-Cultural-Freedom Association based in Gliwice, at Jana Śliwki 13;
- the *Skłotpol* Association based in Warsaw at Puławska 37;
- the *Sztukon* Association based in Lublin, Puławska 9D.

In order to determine the level of physical activity in persons working for particular Independent Cultural Centers, the International Physical Activity Questionnaire (IPAQ) in its short version was used. This tool enables obtaining information on the intensity and frequency of efforts made in the seven days preceding the study; thus a typical week of respondents, as indicated by the IPAQ.

The level of physical activity achieved by the respondents was classified following the IPAQ guidelines (Biernat, Stupnicki, Gajewski, 2007), which distinguish three categories of activity: insufficient (less than 600 MET-min/week),

sufficient (600–1,500 or 600–3,000 MET-min/week) and high (over 1,500 or 3,000 MET-min/week). Each type of physical activity was expressed in MET units min/week. by multiplying the coefficient assigned to a given activity by the number of declared days on which it was undertaken and its duration in minutes per day (Biernat, 2011).

The research was carried out directly. So as to avoid misinterpretation of individual questions and overestimation of the value of the declared efforts by the respondents, the process of filling in the questionnaires was monitored by the researcher. The supervision was aimed at explaining the specificity of the research and answering any questions and doubts concerning particular notions.

Results

Vigorous physical activity

Out of the 104 respondents tested in Independent Cultural Centers located in Poland, 93 persons declared undertaking intensive efforts in the seven days preceding the survey. As the study results showed, these occurred on average on 3.6 days of the week. An average of 44.4 minutes was spent on this type of effort per day, and 150 minutes per week. The energy expenditure in this case amounted to 3,360 MET/min. per week, and the caloric cost – 4080 kcal/week (Table 1).

Table 1. Average level and differences in vigorous physical activity indicators in members of Independent Cultural Centers

Variable	Unit of measure	n	$\bar{x}$	SD	Min	Max
VPA	days/week	93	3.6	1.7	1.0	7.0
	min/day	93	44.4	21.1	10.0	120.0
	min/week	93	150.8	86.1	20.0	420.0
	MET min/week	93	1,206.0	688.7	160.0	3,360.0
	kcal/week	93	1,402.7	822.1	160.0	4,080.0

n – number of cases, $\bar{x}$ – arithmetic mean, SD – standard deviation, Min – minimum result, Max – maximum result.
VPA – vigorous physical activity (8.0 METs).
PA indicators in kcal/week calculated by the EE formula [kcal/week] = MET-min × (weight in kg/60kg) Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) section 4.1 Continuous Variables p. 3.

A further analysis showed that the majority of the respondents declaring vigorous efforts (59.1%) undertook them on average on 3 to 5 days per week, almost one third (29%) – on 1–2 days a week, and 11.8% – on 7 days a week. The vast majority (76.3%) of these activities lasted from 30 to 60 minutes (Table 2).

Table 2. Number and percentage of the respondents in groups selected acc. to frequency and volume of vigorous physical activity

Variable	Category	Total	
		n	%
VPA	1–2 days/week	27	29.0
	3–5 days/week	55	59.1
	7–6 days/week	11	11.8
	Less than 30 minutes/day	15	16.1
	30–60 minutes/day	71	76.3
	Above 60 minutes/day	7	7.5

n – number of cases, % – percentage of respondents.
VPA – vigorous physical activity (8.0 METs).

Moderate physical activity

The analysis of moderate-intensity physical activity showed that it was performed by 90 out of 104 respondents (86.5%). The respondents declared being involved in such efforts on an average of 4.1 days per week, 54.2 minutes a day and 206.5 minutes a week. In this case, the energy expenditure was on average 3,360 METmin/week, and the caloric cost – 3,080 kcal/week (Table 3).

Table 3. Average level and differences in the indicators of moderate physical activity in members of Independent Cultural Centers

Variable	Unit of measure	N	$\bar{x}$	SD	Min	Max
MPA	days/week	90	4.1	2.0	1.0	7.0
	min/day	90	54.2	26.5	10.0	140.0
	min/week	90	206.5	134.1	15.0	840.0
	MET min/week	90	826.0	536.5	60.0	3,360.0
	kcal/week	90	952.5	597.8	75.0	3,080.0

n – number of cases, $\bar{x}$ – arithmetic mean, SD – standard deviation, Min – minimum result, Max – maximum result.
MPA – moderate physical activity (4.0 METs).
PA indicators in kcal/week calculated by the EE formula [kcal/week] = MET-min × (weight in kg/60kg) Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) section 4.1 Continuous Variables p. 3.

Almost half of the respondents (47.8%) declaring moderate intensity physical activity undertook it on 3 to 5 days per week. Most of the respondents (78.9%) spent 30–60 minutes a day on this type of activity (Table 4).

Table 4. Number and percentage of the respondents in groups selected acc. to frequency and volume of moderate physical activity

Variable	Category	Total	
		n	%
MPA	1–2 days/week	23	25.6
	3–5 days/week	43	47.8
	7–6 days/week	24	26.7
	Less than 30 minutes/day	9	10.0
	30–60 minutes/day	71	78.9
	Above 60 minutes/day	10	11.1

n – number of cases, % – percentage of respondents.
MPA – moderate physical activity (4.0 METs).

Walking

The least intensive efforts related to walking without stopping for at least 10 minutes were declared by 101 out of 104 respondents. Walks were taken on average on 6.2 days of the analyzed week, for 65.3 minutes a day and 406.6 minutes a week. The energy expenditure for this type of physical activity amounted to 4,158 METmin/week, and the caloric expenditure was 6,029.1 kcal/week (Table 5).

Table 5. Average level and differences in the indicators of physical activity in walking in members of Independent Cultural Centers

Variable	Unit of measure	n	$\bar{x}$	SD	Min	Max
WALKING	days/week	101	6.2	1.6	1.0	7.0
	min/day	101	65.3	35.9	10.0	180.0
	min/week	101	406.6	249.0	15.0	1,260.0
	MET min/week	101	1341.7	821.7	49.5	4,158.0
	kcal/week	101	1,562.9	1,043.9	45.4	6,029.1

n – number of cases, $\bar{x}$ – arithmetic mean, SD – standard deviation, Min – minimum result, Max – maximum result.
LPA – low-intensity physical activity (3.3 METs).
PA indicators in kcal/week calculated by the EE formula [kcal/week] = MET-min x (weight in kg/60kg) Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) section 4.1 Continuous Variables p. 3.

A further analysis showed that a vast majority of the respondents (78.2%) walked for a minimum of 10 minutes on 6–7 days per week. Most of the respondents (60.4%) spent 30–60 minutes on it on one day (Table 6).

Table 6. Number and percentage of persons active in ICCs in groups selected acc. to frequency and volume of low-intensity physical activity

Variable	Category	Total	
		n	%
WALKING	1–2 days/week	7	6.9
	3–5 days/week	15	14.9
	7–6 days/week	79	78.2
	Less than 30 minutes/day	8	7.9
	30–60 minutes/day	61	60.4
	Above 60 minutes/day	32	31.7

n – number of cases, % – percentage of respondents.
LPA – low-intensity physical activity (3.3 METs).

Classification of the respondents' level of physical activity according to IPAQ

According to the indications adopted in the Polish version of the IPAQ questionnaire (Biernat et al., 2007), only 3.8% of respondents from Independent Cultural Centers could be classified as persons undertaking insufficient physical activity. Over one third of the respondents (38.5%) declared efforts that put them into the category of highly active, and the remaining ones, more than half (57.7%), demonstrated a sufficient level of physical activity (Table 7).

Table 7. Level of weekly volume of physical activity in the respondents acc. to the IPAQ criteria

Variable	Category	Total	
		n	%
PAL acc. to IPAQ	Low (insufficient)	4	3.8
	Moderate (sufficient)	60	57.7
	High	40	38.5

n – number of cases, % – percentage of respondents.
PAL – according to IPAQ – physical activity level according to the IPAQ criteria.

A further analysis of the data showed that those classified as physically active most frequently undertook high-intensity efforts 3 times a week for at least 20 minutes a day (26% of respondents) and low-intensity efforts – 5 times a week for at least 30 minutes (23%) (Table 8).

Table 8. Number and percentage of the respondents with moderate and high level of weekly PA acc. to detailed IPAQ criteria

Variable	Category	Total	
		n	%
PAL acc. to IPAQ	Moderate (3 × 20 min VPA)	26	26.0
	Moderate (5 × 30 min MPA)	5	5.0
	Moderate (5 × 30 min LPA)	23	23.0
	Moderate (V-LPA)	6	6.0
	Vigorous (3 × VPA, 1,500 MET min/week) (CRITERION I IPAQ)	23	23.0
	CRITERION	17	17.0

n – number of cases,% – percentage of respondents
PAL according to IPAQ – physical activity level according to IPAQ criteria

In the case of the respondents classified as highly physically active, 23% reported undertaking vigorous efforts on 3 or more days per week, the energy expenditure of which was at least 1,500 METmin/week, while 17% declared doing various types of physical activity (vigorous, moderate or walking), more than 3,000 METmin/week (Table 8).

Results and discussion

The respondents from Independent Cultural Centers come out as persons pursuing grassroots initiatives that have a real impact on the development of an active as well as healthy lifestyle. Accordingly, it seems beneficial to monitor and research similar social groups and their initiatives. Self-decision on the types of physical activity and other initiatives undertaken within the ICCs allow their members freedom in pursuing individually selected forms of activity.

As the conducted analyses indicate, only 3.8% of the respondents showed an insufficient, according to the IPAQ criteria, amount of physical activity. The results obtained by the respondents of ICCs compared favorably against the results of individual levels of physical activity undertaken in similar atypical research groups, for example, employees promoting health in Zagłębie Dąbrowskie. In the case of the former, the declared participation in moderate efforts covered on average 206.5 minutes per week, and in high-intensity efforts 150 minutes a week. In the case of the latter group, the values amounted to 138 and 102 minutes per week respectively (Dębska, Mynarski, Biernat, Nawrocka, Bergier, 2019).

The comparison also showed more favorable results for the ICCs respondents when confronted with the data derived from selected occupational groups from Warsaw (Biernat, 2011), the majority of whom declared less frequent participation in physical activity compared to the ICCs respondents, who also showed better results in the analyses concerning weekly energy expenditure. They obtained the value of 3,157 METmin/week, which was over 514 units higher with regard to the tested inhabitants of Warsaw (Biernat, 2011).

Accordingly, it may be said that the results obtained by the tested respondents show that physical activity promoted by such niche groups as employees of Independent Cultural Centers can bring beneficial results for people actively pursuing it. Therefore, there is a need for further research and monitoring of this type of unconventional initiatives, which may become an opportunity for promoting an active lifestyle among young people and an effective way of disease prevention.

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CHANGES RELATED TO THE FIRST AID IN WATER LIFESAVING IN POLAND (1962–2020)

Iwona Tabaczek-Bejster[A, B, D]

Institute of Health Sciences, Medical College of Rzeszow University, Poland
ORCID: 0000-0002-1233-6324

Jerzy Kiszka[A, B]

Institute of Health Sciences, Medical College of Rzeszow University, Poland
ORCID: 0000-0002-7361-1019

Grzegorz Konieczny[A, B, D]

Faculty of Health Sciences and Physical Education, Witelona State University of Applied Sciences in Legnica, Poland
ORCID: 0000-0002-6839-1082 | e-mail: gkonieczny@wp.pl

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Abstract In 1962, Water Volunteer Rescue Service (WOPR) was established. From the beginning of its activity, this organization has established cooperation with the Polish Society of Anaesthesiology. In 1997, the regulation of the Council of Ministers was published in the Journal of Laws of the Republic of Poland, defining the safety conditions for people who are swimming, bathing and practicing water sports. WOPR was authorized to perform tasks related to the safety of persons staying at the body of water. In 2007, a breakthrough in the development of the first aid in water rescue took place in Poland. On January 1, 2007, the Law on State Emergency Medical Services entered into force. On its basis, the system of State Emergency Medical Services was created. WOPR has become one of the units cooperating with this system. On January 1, 2012, the new act on the safety of people staying in water areas was introduced. On its basis, radical changes in lifesaving have been made.
The study analyzed the evolution of the first aid rules for lifesavers in Poland. It presents changes in ways of conduct in artificial lung ventilation and chest compressions in drowning people.

Key words water lifesaving, first aid, resuscitation, WOPR, history

Introduction

People in course of their life often died in water during an accident or suicide. Drowning is one of the more common causes of death in young people and is one of the leading causes of death in this age group (Peden, McGee, 2004). The role of lifesavers is to save drowning people and prevent them from dying. Methods of conducting resuscitation procedures and methods of rescuing drowning people have changed over the years following updated knowledge and technical novelties.

In ancient times, the ability to swim was not very popular. Ways of rescuing the drowning were significantly different from those present and were less effective. It was unclear how to restore vital functions in a person with cardiac arrest. Mechanisms associated with drowning were not known, although attempts were made to find ways to help a person who suddenly lost their vital functions.

The oldest example of artificial mouth-to-mouth breathing is found in the Old Testament, in the Second Royal Book. The prophet Elisha brought a boy back to life by putting his mouth to the child's mouth. Hippocrates, who lived between 460–377, was performing further attempts to save lives using tracheotomy. In 1667, R. Hook used lungs inflation with bellows, which allowed to maintain the life of experimental animals (Skalski, 2003a).

The development of modern methods of reviving people rescued from water in the world dates back to the eighteenth century.

Commercial trade by sea and a large number of people working in the Dutch and British ports have contributed to a significant increase in the number of drowning. This situation led in the 1770s to the creation of companies dealing with rescuing drowning people, they attempted to provide adequate artificial ventilation during the first aid. In 1767, the first organization of this type was founded in Amsterdam – the Society for the Recovery of Drowned Persons (Cooper, Cooper, Cooper, 2006).

A detailed description of lung ventilation and intubation was done in 1776 by W. Cullen and Lord Cathacart. In case of ineffective mouth-to-mouth or mouth-to-nose ventilation they recommended administering air with a syringe into the endotracheal tube (Skalski, 2003b).

In the Polish territories, the beginning of resuscitation is considered 1805, when J. Śniadecki published in Vilnius a work entitled *O przypadkach pozornej śmierci i sposobach przywracania tak obumarłych osób do życia* [On cases of apparent death and ways of restoring such dead people to life]. It was a compendium of conduct in life emergency situations based on the experience of doctors from Europe and his own. The author described the mouth-to-mouth method in the following way: "*... At the end, put own lips to the lips of a dead fetus, inflate his chest slowly, and then, by slowly compressing the blown air, squeeze in again and repeat it until the baby breathes on his own...*" (Śniadecki, 1840, pp. 233–290). In the event of failure, a tracheotomy was to be performed. In his work, J. Śniadecki also wrote about double bellows, by means of which air was forced into the lungs and pulled out. He also organized and equipped a rescue point for drowning people (Śniadecki, 1840).

A few years after the introduction of endotracheal tubes and "bellows", they were banned by the Royal Life Saving Society in London due to the high mortality after their use (Skalski, 2003b).

In the nineteenth century, the search for new methods useful in resuscitation began. In France, air insufflation was replaced by D'Etoile's passive movements. In 1882, the first attempts to apply direct heart massage by M. Schiff were carried out (Cooper et al.). In 1891, Dr. F. Mass performed the first effective chest compressions in a man, restoring life to a patient who had stopped the circulation during anesthesia with chloroform (Taw, 1991).

In the twentieth century there was a breakthrough associated with the creation of a framework for resuscitation.

In 1898, the Imperial Society for Sinking Rescue in Kalisz started its activity in Poland, and this year was adopted as the beginning of organized water rescue in Polish territories. In 1902, for the needs of the Society, Dr. L. Wernic published a book entitled: *How to save drowning?* It was the first book in Polish containing a description of methods and ways for rescuing drowning people (Marszal-Hall's, Sylvester's and Lamborde's method) (Wernic, 1994).

In 1947, the American cardiac surgeon C. Beck performed the first successful defibrillation. He used it with a 14-year-old boy who suffered cardiac arrest during cardiac surgery (Beck, Pritchard, Feil, 1947).

In 1954, J. Elam was the first to prove that the air exhaled by the rescuer is sufficient to maintain adequate oxygenation of the victim.

Thanks to these tests, mouth-to-mouth ventilation has been rediscovered and introduced into clinical practice. The descriptions of techniques for external heart massage were gradually improving. In 1958, it was described by W. Kouwenhoven (Cooper et al., 2006).

Dr P. Safar (Baskett, 2001) is considered to be the founder of the principles of saving lives, known all over the world today. Thanks to ABC of resuscitation: A – restoring airways patency, B – breathing, C – external heart massage, it was possible to effectively save life.

P. Safar in his studies on the patency of the upper respiratory tract noticed that in unconscious patients who have an extended neck and supported mandible, the airways open (Safar, Escarraga, Chang, 1954).

P. Safar was nicknamed the "father of resuscitation". He was the first to introduce research on the effects of resuscitation. In 1957 he published the first reference book on resuscitation entitled *ABC of resuscitation*. At the beginning of the 1960s, these guidelines, known currently worldwide as cardiopulmonary resuscitation (CPR), were introduced into clinical practice (14). P. Safar was also the first to apply hypothermia, which was among the later guidelines of resuscitation in 2005 (created by the European Resuscitation Council in the form of the so-called moderate hypothermia) (Safar, Kochanek, 2002).

In 1960, P. Safar presented the results of his work at the symposium of the Scandinavian Society of Anaesthesiologists in Norway. He made friends there with Asmund Laerdal, a producer of toys from Norway. This cooperation resulted in the creation of a mannequin for learning resuscitation called "Resusci Anne". The mannequin's face was inspired by the face of an unknown girl who had drowned in the Seine (Acierno, Worrell, Safar, 2007).

Since then, cardiopulmonary resuscitation has been disseminated not only among professional rescuers.

The first guidelines for cardiopulmonary resuscitation were published in 1966. Since then, these guidelines have been repeatedly updated by two world organizations dealing with resuscitation standards, the American Heart Association (AHA) and the European Resuscitation Council (ERC). All of these recommendations were aimed at restoring not only breathing and heart action, that is resuscitation, but also bringing back the patient's awareness, i.e. reanimation (Kucmin, Płowaś-Goral, Nogalski, 2015).

Changes in the regulations on the first aid in water lifesaving in Poland

In the 1960s when modern methods of resuscitation were created worldwide, an organization dealing with the rescue of drowning was being established in Poland. Earlier, since 1926, the Commission for Water Lifesaving at the Polish Swimming Association (PZP) dealt with matters related to water lifesaving. In 1945, the PZP was revived, and in 1947 a Water Lifesaving Department (Sprawozdanie, 1947) was also established. Its activity bear fruit only after 1952, when on the initiative of D. Bogajewski, an employee of the Academy of Physical Education in Warsaw (AWF) and a PZP activist, water lifesaving entered the curriculum of this university. In the following years, issues related to water lifesaving were included in the curricula of all universities of this type. Since 1958, there has been a dynamic development of water lifesaving in Poland (Witkowski, 1975, pp. 56–60).

On April 11, 1962, by ordinance No. 74 of the chairman of the Main Committee of Physical Culture and Tourism, the Water Volunteer Rescue Service (WOPR) was established. This organization associates volunteers, lifesavers trained in water rescue and first aid.

One of the precursors of water lifesaving in Poland was M. Witkowski (Tabaczek-Bejster, 2012) a graduate of the University of Physical Education in Warsaw and a didactic and academic employee of this university. He was also the author of the book *Saving the drowning*, published in 1958. This manual describes the causes and stages of sinking, there were tips (how to give first aid to the drowning and methods of swimming and pulling the drowning out of water) used in training lifesavers. It also contains legal issues useful in the work of a water lifesaver (Witkowski, 1975, Tabaczek-Bejster, Konieczny, 2020).

In the chapter of the book entitled *Providing help after recovery from the water*, photographs and description of restoring airways patency, ventilation and external cardiac massage are provided. The treatment of an unconscious person, pulled out of the water, has also been discussed. First of all, an ambulance was to be called and then life support was to be performed, such as:

- preparatory activities,
- artificial ventilation,
- indirect heart massage.

In the 1960s, artificial breathing apparatus was introduced for lifesavers work in Poland. It was Polish "AB-9", "AM-4" type device modeled on German "Medi" type devices. Later, they were replaced by Polish "Ambu" type G-12. During the use of the apparatus, the rescue position and the frequency of respirations were the same as for the direct method. A mouthpiece was inserted when the Medi, AB-9, and AM-4 were used. The mask had to adhere well. A spongy pad attached to the mask with a tape was placed under the head in the occipital part, and a clamp was placed on the nose. The rescuer put into the mouth the other end of the cord ended with a mouthpiece and a nose clip. The mouth-to-mouth method was also used on the boat. A rescued person was in a half-sitting position with his head tilted back.

In 1969, PZP finally handed over all matters and documentation related to water rescue services to WOPR Main Board. The central authorities of WOPR introduced new training programs, regulations, instructions and levels of lifesavers. The following degrees were valid: junior lifesaver, lifesaver, senior lifeguard, lifeguard instructor and instructor and lecturer in water rescue (V National Congress, 1987).

Since the beginning of its activity, WOPR has established cooperation with the Society of Polish Anesthesiologists (TAP) in order to exchange experiences during resuscitation. In 1972, there was a scientific symposium TAP and WOPR, dedicated to providing assistance on land and in water (Przylipiak, Witkowski, 1977, pp. 171–186).

In 1975, the WOPR Training Commission issued training instructions no. 1/75, which increased the training requirements for particular water rescue degrees (Training instruction, 1975).

In 1977 a book was published by M. Przylipiak and M. Witkowski titled: *Diving in independent air apparatus and saving drowning*. It provides useful information for people participating in the courses for each step of the water rescuer.

In the second half of the 1970s, the frequency of artificial respiration was modified. It was 10–12 times per minute. When ventilating in small children it was necessary to cover the mouth and nose with the same position of the head and torso as in adults. The air was blown 18–22 times per minute. If there was a cardiac arrest,

cardiopulmonary resuscitation (CPR) was initiated in addition to cardiac arrest. The rescuer kneeled down on the side of the victim and in the manner described above he made artificial breathing first – initially 3 inhalations, and then 15 chest compressions. Next 2 inhalations and 10–12 compressions alternately. When the help was provided by two rescuers, one of them performed first two breaths, and the other 10–12 compressions. Subsequently, after each inhalation into the victim's mouth, 5–6 compressions were applied to the chest (Przylipiak, Witkowski, 1977, pp. 171–186).

Central training of senior rescuers has started since 1985 in the WOPR training center in Tama on the Rajgrodzkie Lake. Due to the fact that lifesavers from all over Poland came there, the subject of training was also unified in the field of first aid (Żagle, 1985).

Subsequent years did not bring significant modifications in the way of cardiopulmonary resuscitation. In 1992, the International Liaison Committee on Resuscitation (ILCOR) was established. It brought together the world organizations involved in creating standards in resuscitation. The founders of the committee were, among others American Heart Association (AHA), European Resuscitation Council (ERC), Australian and New Zealand Committee on Resuscitation (ANZCOR), Resuscitation Councons of Southern Africa (RCSA). ILCOR unified conduct in resuscitation on all continents publishing in 1997 their standards of conduct (Malinowska-Zaprzałka, 1998) in medical journals ("Resuscitation", "Circulation", "British Journal of Anaesthesia").

On June 7, 1997, a regulation of the Council of Ministers was published in the Journal of Laws of the Republic of Poland, which defines the safety conditions for people who are swimming, bathing and practicing water sports. It was the same year in which the ILCOR guidelines for resuscitation were created. The ordinance stipulates that the WOPR is authorized to perform tasks related to the safety of persons staying above the water. It also specifies types of bathing areas and their equipment, the number of lifesavers on a given water area and first aid medical equipment in which a swimming pool and bathing areas should be equipped.

According to Annex 4 of the regulation regarding the ordinance, each lifeboat and each rescue station should contain first aid medical equipment. Annex 6 contained a detailed list of medical equipment, medicines and sanitary articles in which swimming pools and bathing areas should be equipped. Medical equipment was:

- a device for artificial respiration 1 piece,
- portable oxygen inhaler 1 piece,
- straight and curved scissors 2 pieces,
- tourniquet (wide rubber band) 1 piece,
- immobilizing splint 3 pieces,
- a medicine glass 1 piece,
- thermometer 1 piece,
- masks for artificial respiration,
- rubber gloves (Regulation, 1997).

In 1998, the European Resuscitation Council issued guidelines based on recommendations for Cardiopulmonary resuscitation and emergency procedures in cardiac disorders. They were updated every 5 years on the basis of reliable and current studies. The last update took place in 2015 (Table 1).

Table 1. Changes in basic resuscitation procedures in an adult taken out of water in years 1997–2020

ACTION	Guidelines ILCOR 1997	Guidelines ERC 2000	Guidelines ERC 2005	Guidelines ERC 2015
Restoring Airways Patency	Tilting the head back and lifting the mandible or balancing it in the event of spinal injury			
The foreign body in the airways	Perform the Heimlich maneuver	Perform chest compressions	Perform epigastrium's compression	Do not check routinely, delete if visible
Artificial ventilation method	Mouth to mouth or mouth to nose	Mouth to mouth	Mouth to mouth or mouth to nose (in water)	Mouth to mouth
The number of initial rescue breaths	2 breaths lifting up the chest (max 5 attempts)	2 breaths (max 5 attempts, previously the rescuer takes a deep breath)	5 breaths	
Respiratory volume	400–500 ml	700–1000 ml	500–600 ml	
Pulse test	Carotid artery	NO, instead, look for signs of blood circulation	NO	
Place of chest compressions	Lower half of the sternum		The center of the chest	
Depth of compressions	1/3 of the depth of the chest	1/3 of the antero-posterior dimension	4–5 cm	5–6 cm
The frequency of compressions	100/min			100–120/min
Number of rescue breaths	2 effective breaths (max 5 attempts) lasting 1.5 sec.	2 breaths lasting 2 seconds	2 breaths (max 2 ventilation attempts)	2 breaths lasting 1 sec.
The ratio of compressions to breath	15 : 2 when 1 lifeguard 5 : 1 when 2 rescuers	15 : 2	30 : 2	
Shifts of rescuers in compressing the chest	When the rescuer is tired		1–2 minutes	Every 2 minutes
Evaluation of the return of circulation	Every minute		Only if he/she starts to breathe properly	The return ofspontaneouscirculation (coughs, moves)
Keeping CPR for 1 min. before going for help	YES			
Using the AED	NO			YES

Source: own elaboration of ILCOR and ERC guidelines in 1997–2020.

From January 1, 2000, new programs of courses for WOPR lifesavers and instructors as well as specialist trainings were introduced by the resolutions of the WOPR presidium. The previous training instructions have ceased to apply. Small changes in the naming of rescue degrees were introduced: WOPR junior lifesaver, WOPR lifesaver, WOPR senior lifeguard, WOPR instructor, WOPR instructor-lecturer (Resolution, 1999). First aid and resuscitation procedures were taught on courses along with issues related to water rescue. The training stages and programs were in force until December 31, 2009 (Decision, 2009).

The 2000 ERC guidelines resulted in several important changes in the first aid provided by medical personnel and non-medical rescuers included in organizations providing assistance (including WOPR). Heart rate testing was not recommended, as in some cases it was an activity requiring more time than 10 seconds. Instead, two rescue breaths had to be performed and seek signs of blood circulation. The guidelines recommended that chest

compressions and rescue breaths should be carried out only by one witness of the event at a time. The ratio of chest compressions to rescue breaths was 15 : 2. Only medical personnel and rescuers of trained teams such as lifesavers could conduct CPR in two persons. It was also pointed out that there is no need to clean the airways from the water. Cervical spine injury was relatively rare. It was not recommended to stabilize it routinely (Watson, Cummings, Quan, Bratton, Weiss, 2001).

The European Resuscitation Council guidelines of 2005 introduced a new definition of drowning – a process that initially results in a respiratory disorder caused by flooding or immersion in a liquid. This meant that at least the first part of the airways is immersed in water. A person after the drowning episode should have been taken out of the water as soon as possible. The risk of damage to the cervical spine was low in the drowning, at around 0.5%. In the case of a person with respiratory arrest, it was recommended to start ventilating in shallow water as soon as possible with the mouth-to-nose method. The rescue breaths should have been carried out for one minute. If the respiration did not come back after this time, the further course of action depended on the distance from the shore (time to reach up to 5 min. – continue rescue breaths in water, time to reach above 5 min – perform breaths for 1 minute and swim to shore as soon as possible).

After the victim is pulled ashore, chest compressions should begin (Soar et al., 2005).

The breakthrough in the development of first aid in water rescue in Poland took place in 2007, when on 1 January the Act on State Emergency Medical Services (PRM) entered into force. It created the system of State Emergency Medical Services which provides help to every person whose health and life are threatened. WOPR has become one of the units cooperating with the PRM system. Pursuant to the act, water rescuers were obliged to raise their qualifications by completing a qualified first aid course (KPP). The Minister of Health issued a regulation on the organization and conduct of the course. The subject of the 66-hour training was extensive, including the treatment of unconscious and resuscitation of an adult, a child, a baby and a newborn. The training included providing assistance during shock, convulsions, diabetes, myocardial infarction, stroke, poisoning and flooding.

The principles of defibrillation of the injured by the semi-automatic and automatic method were taught. Great emphasis during the course was placed on the management of injuries and triage during mass accidents. After such a course the lifesaver was well prepared for performing qualified first aid. The re-exam (recertification) took place every 3 years.

A lifesaver time having the title of “rescuer” at the same, after completing the KPP course was working on a lido or a swimming pool equipped with a first aid kit R1 (bag or backpack). The medical kit contained:

a) equipment for cardiopulmonary resuscitation:
   - a manual aspirator – 1 piece,
   - a mask for artificial respiration – 1 piece,
   - oropharyngeal tubes for children and adults – 1 set,
   - face mask for children and adults – 1 piece each,
   - a bag valve mask with oxygen reservoir – 1piece,
   - nasal cannula , oxygen mask for an adult and a child – 1 piece each,
   - oxygen cylinder with reducer – 1 piece;

b) dressings;

c) spray for burns and disinfectants (Regulation, 2012).

Following the changes in water rescue in Poland and wishing to adjust the structure of the degrees to the International Life Saving Federation (ILS), WOPR Central Board presidium adopted Resolution No. 5/6/09 of December 5, 2009 on the WOPR lifesavers' and instructors' degrees. From January 1, 2010, the volunteer division introduced the rank of the junior WOPR lifesaver and WOPR lifesaver, while in the professional division – the water rescuer of the swimming pool, inland water lifeguard, sea water lifeguard, and the senior water lifeguard. In addition, three instructor degrees were established: WOPR junior instructor, WOPR instructor, WOPR instructor-lecturer. They lasted until December 31, 2012.

The candidate joining the course for the degree of professional rescuer (swimming pool, inland, sea) must have a WOPR lifesaver degree and the title of "rescuer" after completing the KPP course. Training for professional degrees in their programs had introduced issues in the field of qualified first aid. Improvements were made in helping a person in shock, with injuries and back injuries. CPR was carried out with the use of the first aid kit R1 according to the previously created scenario. The actions using the mannequin – an adult, a child, a baby – were carried out individually or in a team of two rescuers (Decision, 2010).

The new Act on the safety of persons residing in water areas entered into force on January 1, 2012. On the basis of this, radical changes have been introduced in water rescue in Poland. A person who wanted to become a lifesaver had to meet 4 conditions:

a) have knowledge and skills in the field of rescue and swimming techniques (training of water rescuers);
b) other qualifications useful in water rescue (patent or other permission useful in water rescue);
c) complete the KPP course (obtaining the title of a rescuer);
d) perform service or be a member in an entity authorized to perform water rescue (Kołodziej, Tabaczek-Bejster, Dudziak, 2014).

After 50 years, WOPR lost its monopoly on water rescue activities. Over the next years of the Act's existence, over 100 entities authorized to perform this type of activity were established. The largest of them is the Water Rescue of the Republic of Poland, Masurian Volunteer Rescue Service, Masurian Rescue Service. Unfortunately, some of them are only focused on commercial activities. These entities do not always have the required rescue equipment and instructors needed to conduct training. There was also no body authorized to control them. This may translate into a reduction in the level of training of water rescuers, which used to be very high (Tabaczek-Bejster, Kiszka, Ozga, 2018) in the previous years.

In 2015, the European Resuscitation Council (ERC) published the 2015 CPR Guidelines. They included for the first time the "chain of survival in drowning". It consists of five links that should be used during a sinking accident. They have a direct impact on the survival rate in drowning. These include: prevent drowning (be safe in and around water), recognize distress (ask someone to call for help), provide flotation (to prevent submersion), remove from water (only if safe to do so), provide care as needed (seek medical attention). For the first time, these guidelines introduce the use of AED in the sinking algorithm. This will undoubtedly contribute to the need for providing emergency services to the AED, by the administrators of various types of bathing areas in Poland (Truhlář, Deakin, Alfonzo, Bierens, Brattebo, 2015).

In December 2019, the Minister of Health changed the regulation on the course KPP. It states that a water lifeguard with a certificate of passing the qualified first aid exam, the validity of which expires no later than 3 months from the date on which a water lifeguard takes the exam, may proceed to recertification. In addition, a water lifeguard must be employed in units cooperating with the system, work in them or be a member of it (Regulation, 2019).

At the beginning of 2020, the SARS CoV-2 coronavirus epidemic broke out in Poland and in the world. Therefore, the ILCOR has made recommendations for CPR in patients with confirmed or suspected COVID-19. They have been published by the ERC under the name of the COVID-19 Guidelines. They have increased the emphasis on the use of personal protective equipment. Basic resuscitation procedures in adults introduced the necessity to assess the breathing without opening the airway and not placing the rescuer's face next to the victim's mouth. Rescue breathing was abandoned in adults and it was recommended to wear a protective mask on a person whose chest was compressed. If an oxygen mask and an oxygen cylinder are available and there is no training in ventilation with a self-inflating bag, oxygen supply through the oxygen mask and the compression of the chest was recommended. After completion of CPR, it was recommended to wash hands with soap or disinfect them, and contact the health authorities for information on screening tests after contact with a person with suspected or confirmed COVID-19 (Olasveengen et al., 2020).

On March 20, 2020, the government introduced an epidemic throughout the country. The KPP courses and exams were suspended, and many rescuers were not authorized to provide qualified first aid. To enable rescuers to fulfill their tasks, the government extended the validity of certificates expiring during the epidemic period to 60 days from the date of cancellation of the epidemic (Act, 2020).

On April 10, 2021, the Virtual Symposium of the Polish Resuscitation Council is planned on the occasion of the 20th anniversary of activity, at which the new Resuscitation Guidelines 2021 will be presented.

Conclusions

Over the centuries, there has been a significant development of cardiopulmonary resuscitation. In the 1960s, mouth-to-mouth resuscitation was resumed. At present, five rescue breaths should be carried out at the beginning of resuscitation procedures for a person taken out of the water. The effectiveness of indirect heart massage in restoring heart rate in drowning people was also confirmed. In the first breathing apparatus only the exhaled air of the rescuer was used. Currently, breathing apparatus with oxygen from an oxygen cylinder is used. Changes in the field of water rescue in Poland, concerning CPR and first aid were carried out simultaneously with changes occurring in the world.

International organizations associated in ILCOR have created a universal algorithm for basic resuscitation procedures, which in Poland are used by paramedics, units (including WOPR) cooperating with the State Emergency Medical Services (PRM) and people trained in the first aid. The use of new devices to conduct artificial respiration and the introduction of a mandatory KPP course for water rescuers has improved the quality of resuscitation procedures. Currently, the rescuer working alone in the swimming pool is able to conduct CPR from the first minutes of cardiac arrest until the arrival of the ambulance. Taking into account the fact that professional lifesavers carry out a small number of resuscitations in a year, one should consider introducing more frequent first aid training. This refresher course should take place before the summer season. Additional research in this area is necessary. It would allow determining the optimal frequency with which mandatory refresher training for water rescuers could be introduced. Due to the epidemiological situation in Poland and in the world, there is a need for continuous self-improvement of their skills and acquiring the latest knowledge by water rescuers.

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GENETIC VARIATION AS A POSSIBLE EXPLANATION FOR THE HETEROGENEITY OF PAIN IN TENDINOPATHY: WHAT CAN WE LEARN FROM OTHER PAIN SYNDROMES?

Nonhlanhla S. Mkumbuzi[A, B, D]

Health through Physical Activity, Lifestyle and Sports Research Centre, Division of Physiological Sciences, Department of Human Biology, University of Cape Town. Anzio Road, Observatory 7935, Cape Town, South Africa
International Federation of Sports Medicine (FIMS) Collaborative Centre of Sports Medicine, South Africa
ORCID: 0000-0002-4982-0662 | e-mail: nonhlanhla.mkumbuzi@uct.ac.za

Michael Posthumus[A, D]

Health through Physical Activity, Lifestyle and Sports Research Centre, Division of Physiological Sciences, Department of Human Biology, University of Cape Town. Anzio Road, Observatory 7935, Cape Town, South Africa
High Performance Centre, Sports Science Institute of South Africa, Boundary Road, Newlands, 7725, Cape Town, South Africa
ORCID: 0000-0002-8806-8805 | e-mail: mposthumus@ssisa.com

Alison V. September[A, D]

Health through Physical Activity, Lifestyle and Sports Research Centre, Division of Physiological Sciences, Department of Human Biology, University of Cape Town. Anzio Road, Observatory 7935, Cape Town, South Africa
International Federation of Sports Medicine (FIMS) Collaborative Centre of Sports Medicine, South Africa
ORCID: 0000-0003-0950-286X | e-mail: alison.september@uct.ac.za

Malcolm Collins[A, D, E]

Health through Physical Activity, Lifestyle and Sports Research Centre, Division of Physiological Sciences, Department of Human Biology, University of Cape Town. Anzio Road, Observatory 7935, Cape Town, South Africa
International Federation of Sports Medicine (FIMS) Collaborative Centre of Sports Medicine, South Africa
ORCID: 0000-0002-2564-0480 | e-mail: malcolm.collins@uct.ac.za

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract The mechanisms of pain in tendinopathy are unclear. Current theories implicate tendon structural changes, neovascularisation, inflammation or changes in central pain processing. As with other types of musculoskeletal pain, tendon pain has high interindividual variability, which could be attributed to genetic variation. Notably, the association between certain genetic polymorphisms and other pain syndromes is well established in the literature. Therefore, the investigation of the mechanisms of pain in tendinopathy could extend to include genetic variation as a possible explanation for the clinical features of tendon pain. This review summarises the current knowledge on genetic contributors to other pain syndromes and highlights findings that are relevant to chronic tendon pain. In particular, based on the current hypotheses on the possible sources of tendon pain, it focuses on findings that relate to genes that encode structural connective tissue components, inflammatory markers, ion channels and catecholamines and how they may relate to chronic tendon pain. In the absence of a definitive mechanism of tendon pain, an

a priori genetic approach that is guided by these current hypotheses may help elucidate the mechanisms of tendon pain which may allow a more rational approach to research and treatment.

Key words tendon pain, genetics, extracellular matrix genes, inflammation genes, COMT

Introduction

Tendinopathies are common in recreational and professional athletes (Lagas et al., 2020), and in certain occupations (Owens et al., 2013). The main presenting complaint in tendinopathy is pain of insidious onset (Silbernagel, Hanlon, Sprague, 2020), which is not proportionate to tissue damage (Docking, Ooi, Connell, 2015), is difficult to manage (Cook, Purdam, 2009) and persists even after resolution of other functional outcome measures (Van Ark et al., 2018). This is not surprising because its source and/or mechanisms are currently not fully understood. Consequently, several theories have been proposed explaining the potential sources of pain in tendinopathy, with no consensus on what the exact mechanisms of pain are in tendinopathy. Current theories implicate structural changes in the tendon (Bakkegaard, Johannsen, Højgaard, Langberg, 2015), neovascularisation (Mousavizadeh et al., 2014), inflammation (Abate et al., 2009; Battery, Maffulli, 2011; Dean et al., 2015), biochemical changes (Lian et al., 2006; Schizas et al., 2012), ion channel abnormalities (Rio et al., 2014), as well as alterations in central pain modulation (Plinsinga, Brink, Vicenzino, van Wilgen, 2015; Tompra, Van Dieen, Coppieters, 2016). The aetiology of chronic tendon pain remains poorly understood and most likely presents with its own unique clinical features. However, it is not implausible to assume that chronic tendon pain shares a proportion of its physiology (Caneiro et al., 2020) and burden (Mc Auliffe et al., 2017; Mkumbuzi et al., 2020) with other types of chronic painful musculoskeletal (MSK) conditions.

As with other chronic painful MSK conditions, tendon pain responses are characterised by robust inter-individual variability in sensitivity and susceptibility (Fillingim, Wallace, Herbstman, Ribeiro-Dasilva, Staud, 2008), and mounting evidence suggests that a significant portion of pain variability can be explained by genetics (Bjorland, Moen, Schistad, Gjerstad, Røe, 2016; Foulkes, Wood, 2008; Veluchamy, Hebert, Meng, Palmer, Smith, 2018). It is interesting that the estimated heritability of nociceptive and analgesic sensitivities is as much as 76% (Chidambaran, Gang, Pilipenko, Ashton, Ding 2019; Diatchenko et al., 2005; Peters et al., 2013; Ruau et al., 2012). Consequently, several genetic polymorphisms have been associated with specific pain syndromes (Foulkes, Wood, 2008), pain perception and analgesic use (Hooten, Hu, Cunningham, Iii, 2019; Olesen et al., 2018; Packiasabapathy, Horn, Sadhasivam, 2019; Wang, Wei, Xiao, Chang, Zhang, 2019), and response to physiotherapy treatment (Govil et al., 2020).

The aim of this narrative review was therefore, to summarise the current knowledge on genetic contributors to chronic pain in other pain syndromes, which could potentially also be considered for chronic tendon pain. Based on the current hypotheses on the possible sources of tendon pain, this narrative review therefore focused on findings that relate to genes that encode structural connective tissue components, inflammatory markers, ion channels and catecholamines. In the absence of a definitive source and/or mechanism of pain in tendinopathy, an *a priori* genetic approach guided by these current hypotheses may assist in identifying potential biological mechanisms to be considered for tendon pain which may also inform a more rational approach to its research and development of treatment paradigms.

The structural changes hypothesis: Extracellular matrix components and regulators

The *COL11A1* and *COL11A2* genes encode the a1 and a2 chains of the minor fibrillar type XI collagen. Individuals with knee osteoarthritis (OA) who had a *COL11A2* rs16868943 GG genotype had on average a higher heat pain tolerance (Ho et al., 2017). Additionally, an increased risk of developing OA was reported in the *COL11A2* knockout mouse model (Lapvetelainen et al., 2002). While *COL11A2* has not itself been associated with OA risk in humans, variations in the *COL11A1* gene have been implicated with risk (Raine, Dodd, Reynard, Loughlin, 2013). Additionally, mutations in the *COL11A2* gene have also been associated with osteochondroplasia (Avcin et al., 2008) and non- ocular Stickler's syndrome (Vuoristo, Pappas, Jansen, Ala-Kokko, 2004), both of which share clinical features with OA. It is tempting to speculate that *COL11A2* might not only be associated with risk of developing these conditions but potentially in the development of the associated pain.

Although the genotypes were not independently associated, the inferred T-C-T haplotype constructed from the *COL11A1* rs3753841 (T/C), *COL11A1* rs1676486 (C/T) and *COL11A2* rs1799907 (T/A) was previously associated with increased risk of Achilles tendinopathy in two independent populations (Hay et al., 2013). In addition, the *COL11A1* rs3753841 TT genotype and the inferred T-C haplotype constructed from *COL11A1* rs3753841 and rs1676486 was previously associated with carpal tunnel syndrome (CTS) (Dada, Burger, Massij, de Wet, Collins, 2016). *COL11A1* rs3753841 was also independently associated with elbow tendon pathology (Alakhdar Mohmara et al., 2020). Although these studies did not specifically investigate the association of the type XI collagen gene variants with tendon pain, this should be explored in future work. It would also be interesting to investigate the possible association of other collagen genes with tendon pain.

The matrix metalloproteinases (MMPs) are a family of enzymes that have been implicated in pain. Individuals with a *MMP1* rs1799750 GG genotype on average presented with higher temporomandibular joint pain scores (Planello et al., 2011). This finding was replicated in an independent cohort of low back pain patients where individuals with the GG genotype also presented with higher pain scores on the McGill Pain Questionnaire as well as more disability (Jacobsen et al., 2013). In addition, expression of *MMP10* mRNA was significantly increased in surgical patients with pain compared to pain free controls in a study by Richardson, Doyle, Minogue, Gnanalingham, Hoyland (2009). Furthermore, in animal models, *MMP2* expression was elevated in models of neuropathic pain (Miranpuri et al., 2016). Additionally, the roles of MMPs, in particular *MMP*-2 and *MMP*-9, in facilitating inflammatory pain have been demonstrated in various studies where these enzymes are required in the early and late stages of neuropathic pain development (Ji, Gereau, Malcangio, Strichartz, 2009). Interestingly, their inhibition led to pain relief (Li et al., 2016) and decreased mechanical allodynia in rodent models (Kular et al., 2012). Future studies should therefore also specifically investigate the possible association of variants within the family of *MMP* and tissue inhibitors of metalloproteinases (*TIMP)* genes, which have previously been associated with Achilles tendinopathy (Raleigh et al., 2009, El Khoury, Ribbans, Raleigh, 2013; Kang et al., 2019), with tendon pain.

The caspases (CASP), which are protease enzymes involved in apoptosis and inflammation (Berta, Lee, Park, 2017; Joseph, Levine, 2004), are another family of enzymes that are implicated in pain. CASP-6 regulates chronic pain via microglial inflammatory signalling, most likely through TNF-a secretion (Berta et al., 2017). Additionally, inhibition of CASPs-1, -2, -3, -8 and -9 attenuated pain related behaviour in HIV/AIDS and cancer neuropathy models (Joseph, Levine, 2004). This suggests that caspase signalling pathways contribute to pain. This is further demonstrated by an association between the -1263 *CASP-9* rs4645978 promoter variant with low back pain (Mu, Ge, Zuo, Chen, Huang, 2013). In this study, carriers of the minor G allele were overrepresented in the pain

group compared to their pain-free compatriots. Similarly, Guo et al. (Guo, Liu, Zhang, Guo, Wu, 2011) showed an association between the -1263 *CASP-9* rs4645978 GG genotype with discogenic low back pain. Since variants within *CASP8* have been associated with tendinopathy in some (Seale et al., 2020), but not all studies (Kang et al., 2019), future work should also consider it and other *CASP* genes as candidates for association with tendon pain.

Tendon pain as a channelopathy: Ion channels

Ion channels are very important in the pain pathway, where they manage the generation and processing of pain signals. Sodium, potassium and calcium channels are the main ion channels in neuronal transmission in nociceptors and have been firmly implicated in human pain disorders (Waxman et al., 2014). In particular, voltage-gated sodium channel 1.7 (Nav1.7) is expressed in nociceptors and amplifies subthreshold stimuli. Unsurprisingly, a number of clinical effects such as primary erythermelalgia, paroxysmal extreme pain disorder and congenital insensitivity to pain have been observed in individuals with gain of function and loss of function Nav1.7 mutations, respectively (Estacion et al., 2009; Reimann et al., 2010). In addition to these rare diseases that result from high impact mutations, variants in the gene encoding the a subunit of the sodium voltage gated channel 1.7 (*SCN9A)* were also associated with subtle effects in modulating risk and severity of pain in acquired pain conditions. For instance, the *SCN9A* rs6746030 variant results in an amino acid substitution of arginine to tryptophan at codon 1150 of the a subunit of Nav1.7, which enhances cell excitability of dorsal root ganglia (Estacion et al., 2009). Some studies have demonstrated that the minor rs6746030 A allele (tryptophan substitution) was associated with increased pain reports in individuals with OA, sciatica and phantom limb pain (Reimann et al., 2010) as well as postoperative pain (Duan et al., 2016) and small fibre neuropathy (Hoeijmakers, Merkies, Gerrits, Waxman, Faber, 2012). Additionally, functional characterisation of two rare non-synonymous mutations of *SCN9A,* methionine to threonine substitution (rs201561928) and threonine to isoleucine (rs200470541) at codons 1863 and 1607, respectively demonstrated gain of function changes consistent with an increase in neuronal excitability in a diabetic neuropathy cohort (Blesneac et al., 2018). Similarly, rare mutations in the *SCN10A* and *SCN11A* genes, encoding Nav1.8 and Nav1.9, respectively have also been shown to contribute to inflammatory and neuropathic pain (Huang et al., 2013) and familial episodic pain (Zhang et al., 2013), respectively (Table 1). However, other authors have not been able to replicate these results in independent cohorts (Holliday et al., 2012). The potential relevance of Nav to pain in tendinopathy was demonstrated by Gammaitoni et al. (2013) who reported success with topical lidocaine in managing patellar tendinopathy pain. As lidocaine provides pain relief by blocking Nav channels, their results suggest that peripheral Nav channels play a role in tendon pain; therefore, variants in sodium channels may well affect the pain profile in tendinopathy.

Variants in genes encoding other ion channels such as voltage gated potassium channels (Kv) and voltage gated calcium channels (Cav) have also been associated with chronic painful conditions. The rs734784 variant in potassium voltage-gated channel delayed rectifier subfamily S, member 1 (*KCNS1*) was associated with higher pain in healthy controls and in phantom limb pain, however, this variant did not associate with post mastectomy pain (Costigan et al., 2010). In addition, a number of variants in voltage gated, inward rectifying and two pore potassium channel genes were associated with risk and severity of persistent pain following surgery (Chidambaran, Gang, Pilipenko, Ashton, Ding, 2019) (Table 1). Voltage gated Ca^{2+} channels constitute the main pathway for depolarisation mediated Ca^{2+} influx into neurons. Genes that encode these Ca^{2+} channels have been implicated in painful conditions. For example, *Cacna2d3,* the gene that codes for the a253 subunit of the voltage dependent calcium-

Table 1. Genetic variants in extracellular components and regulators, ion channels, inflammatory mediators and cytokines; and in the catecholaminergic system that have been implicated in other pain syndromes

	Protein(s)	Gene	Polymorphism (s)	References
Extracellular Matrix Components and Regulators	Type XI Collagen	*COL11A1*	rs1676486 (C/T), rs3753841 (T/C)	Raine et al., 2013; Hay et al., 2013
		COL11A2	rs16868943(G/A)	Ho et al., 2017
	Matrix Metalloproteinases (MMPs)	*MMP1*	rs1799750 (G/-)	Planello et al., 2011
		CASP9	rs4645978 (A/G)	Mu et al., 2013
Ion Channels	Sodium Channels	*SCN9A*	rs6746030 (G/A)[1], rs201561928 (T/G)[2], rs200470541 (G/A)[3]	Estacion et al., 2009; Reimann et al., 2010; Duan et al., 2016; Hoeijmakers et al., 2012; Blesneac et al., 2018
		SCN10A	rs968515082 (T/G)[4]	Huang et al., 2013
		SCN11A	rs138607170 (C/T)[5], rs483352921 (C/G)[6]	Zhang et al., 2013
	Potassium Channels	*KCNS1*	rs734784 (A/G), rs13043825 (G/T)	Chidambaran et al., 2019; Costigan et al., 2010
	Calcium Channels	*CACNA2D3*	rs6777055 (A/C)	Neely et al., 2010
		CACNG2	rs4820242 (G/A), rs2284015 (C/G), rs2284017 (T/C)	Bortsov et al., 2019; Neely et al., 2010
	Acid Sensing Ion Channels	*ASIC*	Asic gene knockout model	Vick, Askwith, 2015
Inflammatory Mediators and Cytokines	COX-2	*PTGS2*	rs2383515 (G/T), rs5277 (G/C), rs5275 (T/C), rs2206593 (G/A)	Reyes-Gibby et al., 2009; pplebaum et al., 2015
	Tumour Necrosis Factor	*TNF-a*	rs1800629 (GA)	Reyes-Gibby et al., 2009
	Interleukins	*IL1A*	rs1800587 (G/A/C/T)[7]	Solovieva et al., 2004; Moen et al., 2014
		IL1B	rs16944 (G/A)[8] rs1143634 (G/A)[9]	Bessler et al., 2006 Slodovieva et al., 2004
		IL1R1	rs2110726 (G/A)	McCann et al., 2012
		IL1R2	rs11674595 (T/C)	Stephens et al., 2014
		IL1RN	rs2234677 (G/A)[10], rs2234679 (G/C)[11], rs9005 (G/A)[12]	Moen et al., 2014; Slodovieva et al., 2004
		IL6	rs2069840 (C/G) rs1800795 (C/G)	Białecka et al., 2016 Stephens et al., 2017
		CXCL8 (IL8)	rs4073 (A/C)	Stephens et al., 2014
		IL13	rs1295686 (T/A)	McCann et al., 2012
		IL10	rs3024505 (G/A), rs3024498 (T/C), rs3024496 (A/G), rs1878672 (G/A), rs1518111 (T/C), rs1518110 (A/C), rs3024491 (C/A)	Stephens et al., 2014
		IL16	rs4778889 (T/C)	Gan et al., 2010
Catecholaminergic System	Catechol-o- methyltransferase	*COMT*	rs6269 (A/G), rs4633 (C/T), rs6267 (G/T), rs4818 (C/G), rs4680 (G/A)[13], rs165774 (G/A), rs165774 (G/A)	Diatchenko et al., 2005; Li et al., 2017; 2014; Barbosa et al., 2012; Martinez-Jauand et al., 2013; Martire et al., 2016; Knisely et al., 2018

[1] Arg1150Trp; [2] Met1863Thr, Met1852T (www.ncbi.nlm.nih.gov/clinvar, Blesneac et al., 2018); [3] Thr1607Ile, Thr1596Ile (www.ncbi.nlm.nih.gov/clinvar; Blesneac et al., 2018); [4] Ile1706Val; [5] Arg225Cys; [6] Ala808Gly; [7] -889C/T polymorphism; [8] -511 G is allele 1 and -511 A is allele 2; [9] C+3954T (Phe105Phe); [10] G1812-A; [11] G1887-C; [12] T11100-C;[13] Val158Met.

channel complex, has been associated with thermal pain-related behaviour in animal studies (Neely et al., 2010). In healthy volunteers, the rare *CACNA2D3* rs6777055 C allele was also associated with reduced acute thermal pain while individuals with a CC genotype showed reduced risk for chronic back pain post discectomy (Neely et al., 2010). Additionally, *Cacng2* variants (*Cacng2* encodes for the y2 transmembrane AMPA receptor protein stargazin) affect susceptibility to chronic pain after nerve injury in mice (Neely et al., 2010). In humans, an association was observed between increased susceptibility to pain after mastectomy and the A-C-C haplotype constructed from the *CACNA2* rs4820242, rs2284015, and rs2284017 intronic variants (Bortsov et al., 2019).

Other ion channels whose expression may be modulated in tendinopathy are acid sensing ion channels (ASICs). The role of ASICs in pain has been demonstrated in rodent studies where *Asic* gene knockout mice were resistant to mechanical hyperalgesia (Vick, Askwith, 2015) as well as being linked to migraine in humans (Dussor, 2015). ASICs have also been associated with other painful conditions that, much like tendinopathy, involve acidosis, inflammation and ischaemia (Rio et al., 2014).

The inflammatory hypothesis: Inflammatory mediators and cytokines

A number of inflammatory mediators such as cytokines are also important in the pathology of painful tendinopathy. These cytokines include TNF-a, FGF, TGF-p and the interleukin family (Dakin, Dudhia, Smith, 2014). In particular, IL-1a, IL-ip and IL-33, with a signalling pathway through the activation of mitogen activated protein kinases (MAPKs), stimulate mediators of inflammation causing the onset of pain and extracellular matrix (ECM) breakdown (D'Addona, Maffulli, Formisano, Rosa, 2017). Research in other chronic painful conditions has shown some associations between cytokine gene variants and pain. For instance, a study on lung cancer patients showed that certain genotypes for *PTGS2,* which encodes Cyclooxygenase- 2 (COX-2), and Tumor Necrosis Factor alpha (*TNF-a)* polymorphisms are protective and permissive to pain, respectively (Reyes-Gibby et al., 2009) (Table 1). However, the *PTGS2* G-G-T-A haplotype constructed from rs2383515, rs5277, rs5275 and rs2206593 was associated with post-treatment pain following endodontic treatment (Applebaum, Nackley, BairMaixner, Khan, 2015). In a study of women with breast cancer, carriers of the minor A allele of *IL1R1* rs2110726 reported less breast pain while those with the minor A allele of *IL13* rs1295686 had higher pain scores (McCann et al., 2012). Stephens et al. (2014) also showed that *IL1R2* rs11674595 and the *IL10* haplotype A8 (Table 1) were associated with persistent postoperative pain following breast cancer surgery. In other work, Stephens and colleagues also showed that variants in *IL6, CXCL8 (IL8), and TNF* are associated with the development and maintenance of mild persistent breast pain after breast cancer surgery (Stephens et al., 2017) (Table 1).

A study from China on females diagnosed with endometriosis also showed an increased representation of the C allele of rs4778889 in the *IL16* gene compared to healthy controls and particularly in those with higher self-reported pain (Gan et al., 2010). These results were not replicated among women from a study in Iran (Azimzadeh, Khorram Khorshid, Akhondi, Shirazi, 2016). Individuals carrying at least one G allele of *IL6* rs1800795 also reported higher pain scores in the postoperative period following total hip replacement (Białecka et al., 2016). Additionally, simultaneous carriage of other interleukin-1 variants, *IL-1 RNA* and *IL-1a* has been shown to increase the pain intensity and duration in chronic low back pain (Solovieva et al., 2004) (Table 1). This suggests that *IL-1a and IL-1^* variants may promote or prolong low back pain. Furthermore, variants in *IL1A* rs1800587 affected pain scores and pressure pain threshold in a cohort of patients with lumbar radicular pain. In this cohort, the rs1800587 T allele was associated with an enhanced promoter activity resulting in increased gene expression which enhances the

release of IL-1a and hence the inflammatory response and pain report (Schistad, Jacobsen, Røe, Gjerstad, 2014). Furthermore, an association between the *IL1A* rs1800587 variant and pain intensity was observed in a cohort from Finland, of middle-aged men with low back pain (Solovieva et al., 2004). Similarly, Moen, Schistad, Rygh, Re, Gjerstad (2014) showed that in lumbar radicular pain, patients with the *IL1A* rs1800587 T allele in combination with the *IL1 RN* rs2234677 A allele had more pain and a slower recovery than other patients. Bessler et al. (2006) did not, however, show a relationship between postoperative pain or morphine use and *IL1B* variants in a cohort of women undergoing transabdominal hysterectomy (Table 1).

Although the association with pain was not investigated, several studies have investigated the association of interleukin gene variants with risk of tendinopathy. In one, the AA genotype of *IL6R* rs2228145 (C/A) was associated with reduced risk of developing CTS in a South African cohort (Burger, de Wet, Collins, 2015). In another, while variants within the *IL-1^*, *IL-6* and *IL-1RN* genes were not independently associated with Achilles tendinopathy risk, when found with the *COL5A1* rs12722 (C/T) variant, they were collectively implicated in modulating risk of Achilles tendinopathy (September et al., 2011). It is interesting to note that a study by Suijkerbuijk et al. (2020) implicated variable cytokine expression, specifically *ILip*, *IL6* and *IL-6* Receptor, in the context of a genetic dependent risk model using fibroblast cells. Taken collectively, the importance of the inflammatory pathway in tendinopathy is growing, it would be of interest to further explore the relationship between interleukin genes and tendon pain.

The central pain mechanisms hypothesis: COMT

Available evidence also suggests that tendon pain may be a result of defective central pain inhibition (Plinsinga et al., 2015; Tompra et al., 2016). The catecholaminergic system plays a crucial role in the facilitation or inhibition of nociceptive transmission (Millan, 1999). Abnormalities in catecholamine physiology are associated with decreased activity of catechol-o-methyltransferase (COMT), an enzyme which inactivates catecholamines. As a result, *COMT,* the gene that encodes the enzyme, is one of the most frequently studied of pain genes and has been associated with differential pain sensitivity under experimental and pathological conditions (Baumbauer et al., 2020) as well as with anxiety, depression, and other psychological traits that influence the perception of pain (Fernandez-De-Las-Penas et al., 2019).

Most commonly, various studies have demonstrated the association between Val/Met substitution at codon 158 in the *COMT* gene (rs4680) and numerous pain disorders (Tammimaki, Mannisto, 2012). Individuals homozygous for the Val variant have three to four times higher activity of the COMT enzyme and hence reduced pain sensitivity compared to homozygotes of the Met genotype (Diatchenko et al., 2005) whose variation leads to decreased COMT thermostability, activity and increased pain report in experimentally induced pain (Fernandez-De-Las-Penas et al., 2019) and in orofacial pain (Tchivileva et al., 2011). Furthermore, this variant has also been associated with Parkinson's disease related pain (Lin et al., 2017), fibromyalgia pain sensitivity (Barbosa et al., 2012; Martnez-Jauand et al., 2013), depression and experimental pain (Fernandez-De-Las-Penas et al., 2019), and variability in OA pain (Martire et al., 2016).

Other *COMT* variants such as rs6269, rs4633 and rs4818 were also associated with low back pain related disability in a mixed European cohort; the minor G, C and G alleles of these three polymorphisms were associated with lower baseline disability scores (Omair et al., 2015). Carriers of the rs4818 CC genotype were also over-represented in a cohort of fibromyalgia from Brazil (Barbosa et al., 2012) and the minor C, G and A alleles of rs4633, rs4818 and rs4680, respectively, were over-represented in other fibromyalgia cohorts though not associated with

pain (Brenton et al., 2017). *COMT* rs6267 has also been associated with Parkinson's disease pain wherein the minor T allele presented with higher pain scores (Li, Chen, Yin, Zhang, 2014). In addition, *COMT* rs165774 showed an association with heat pain; the wild type GG genotype with lower pain threshold (Mladenovic et al., 2018).

In addition, *COMT* variants have also been associated with chronic post-surgical pain (Lee, Delaney, Keogh, Sleeman, Shorten, 2011) in which individuals carrying the wild type *COMT* rs4818 CC genotype presented with lower pain scores than those with the CG and GG genotypes following molar extraction. While the high pain A-C-C-G haplotype constructed from rs4663, rs4680 and rs6269 and rs4818 was associated with severe pain after breast cancer surgery (Knisely et al., 2018). Additionally, *COMT* variants have been associated with post-operative analgesic response (Sadhasivam et al., 2014). In the latter study, minor G, C, G and A allele carriers of rs6269, rs4633, rs4818, and rs4680 were three times more likely to require analgesic intervention than homozygotes of the major alleles. *COMT* haplotypes have also been shown to affect response to analgesia in temporomandibular joint disease (Tchivileva et al., 2011). Some authors have however not replicated these findings (Kambur et al., 2013).

Wang et al. (2019) found no association between rs4680 and chronic post-surgical pain following caesarean section. Additionally, in other cohorts, there were no associations observed between *COMT* variants and chronic pain conditions such as Parkinson's disease related pain (Li et al., 2014), pain sensitivity in chronic widespread pain (Nicholl et al., 2010), chronic lower back pain (Omair et al., 2015), pain sensitivity in fibromyalgia (Park et al., 2016), vulvodynia (Patanwala et al., 2017) and chronic post-operative pain (Kolesnikov et al., 2013). The HUNT study was also unable to show any associations between *COMT* genotypes and twelve musculoskeletal conditions in a large Norwegian cohort (Hagen, Pettersen, Stovner, Skorpen, Zwart, 2006). Moreover, no associations were observed between recovery and pain intensity in a European cohort of whiplash injury (Rydman et al., 2017), migraine headache in a cohort from Japan (Takigawa, Kowa, Nakashima, 2017) or pancreatitis in an independent cohort (van Esch et al., 2011). These conflicting results among studies on the association between genetic and clinical variables may reflect the heterogeneity of pain conditions, related to potential subtypes of pain phenotypes, and the small sample sizes of some of the reported studies. It is important to note that three haplotypes of *COMT* (rs6269, rs4818 and rs4680) account for about 11% of the variability in pain perception and given the polygenic nature of pain perception, this is a substantial contribution (Diatchenko et al., 2005).This underscores the significant role that COMT likely plays in pain chronification.

Variants in *COMT* have also been associated with depression and other mood disorders (Femandez-De-Las-Penas et al., 2019). The potential role of the Val/Met variant in pain could be because individuals with the Met/Met genotype of the Val/Met substitution at codon 158 (rs4680) have greater activation of the limbic regions (anterior cingulate cortex-ACC) of the brain in response to emotionally challenging circumstances and negative stimuli such as pain (Smolka et al., 2005) and lower activation of the dorsolateral prefrontal cortex (Egan et al., 2001) when compared to Val/Val. The ACC is a key structure of cortical pain processing that is involved in the affective evaluation of pain as well as anti-nociception (Boadas-Vaello, Homs, Reina, Carrera, Verdu, 2017).

Additionally, Met/Met individuals also have higher pain sensitivity and dysfunctional p- opioid receptor mediated mechanisms in the parahippocampal regions when challenged with prolonged pain (Nascimento et al., 2019). The latter region has an integral role in episodic memory and emotional pain processing. In addition, *COMT* rs6267 GT genotype was associated with depression and Parkinson's disease pain (Lin et al., 2017). Another *COMT* variant that has been associated with cognition is rs4818, where the wild type CC genotype has also been shown to have lower efficiency at processing emotionally arousing stimuli (Roussos, Giakoumaki, Pavlakis, Bitsios, 2008).

This may predispose carriers to stress and dysfunctional responses in the face of disadvantageous situations such as chronic pain. The collective data is therefore suggesting that sequence variations within the *COMT* gene may reduce opioid mediated inhibitory control of pain, impact brain activity in cognitive domains and hence alter both the physiological and psychological domains of pain processing in a chronic pain condition. Chronic tendon pain affects mood and general affect in sufferers (Mkumbuzi et al., 2020), as well as being associated with altered conditioned pain modulation (Tompra et al., 2016) which is a proxy for the internal analgesic system. Since the internal analgesic system and mood are both reliant on COMT, any aberrations in COMT are relevant to the study of chronic tendon pain.

Conclusion

In conclusion, the causes of pain in tendinopathy are still unknown. As genetic variation is implicated in a variety of other pain conditions, a plausible extension of this work would be to explore the genetics of the main symptom in tendinopathy, pain, to further characterise its underlying mechanisms. Some of the genes that have previously been implicated in the pain associated with other conditions are also of interest in tendinopathy as they encode components of the tendon ECM, ion channels, inflammatory mediators and the internal analgesic system (Table 1). This review is by no means exhaustive; however, it does provide a theoretical framework on which to test the hypothesis that genetic variations previously associated with other pain conditions could, at least in part, modulate the variability observed in the pain syndrome of chronic tendinopathy. Using available and emerging technologies will allow us to identify the various genes that are implicated in tendon pain and this, in turn, allows us to explore the possible biological mechanisms underlying tendon pain. Hence, studying the genetic contribution of tendon pain may help identify the mechanisms involved in tendon pain as well as provide new therapeutic targets or strategies.

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THE INFLUENCE OF LIFE STRESS, COMPETITIVE TRAIT ANXIETY, AND SLEEP DISTURBANCE ON INJURY SUSCEPTIBILITY IN FOOTBALL

Umut Dikmen[A, B, C, D, E]

Institute of Exercise Training and Sport Informatics, German Sport University Cologne, Cologne, NRW, Germany
ORCID: 0000-0002-3005-6174 | e-mail:Umutd08@gmail.com

Sebastian Schwab[A, B, C, D, E]

Institute of Exercise Training and Sport Informatics, German Sport University Cologne, Cologne, NRW, Germany

[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract *Aim:* The purpose of the current study was to analyse the effect of life stress, competitive trait anxiety and sleep disturbance on injury susceptibility in football players.
Methods: Participants were 67 male football players from different teams in Cologne ranging in age from 18 to 25 years (M = 21.09 years; SD = 2.69). Participants filled out four questionnaires: The Holmes-Rahe life stress scale, the sport competition anxiety test (SCAT), the Pittsburgh Sleep Quality Index (PSQI), and the Oslo Sports Trauma Research Centre (OSTRC) questionnaire on health problems.
Results: Results suggest that while life stress may increase the injury susceptibility, competitive trait anxiety, and sleep disturbance have no effect on injury susceptibility. Concerning this descriptive data, 53.7% (36/67) of the players stayed away from the football field for at least one week, and about 23.8% (16/67) of them did not have any injury during this four months' period.
Conclusion: Our findings suggest that high life stress levels caused athletic injury; for these reasons the psychological dimension should be considered and adapted in the training. Although we found no significant correlation between competitive trait anxiety, and sleep disturbance on injury susceptibility, longitudinal studies are required to assess the effect of life stress, anxiety, and sleep disturbance on injury susceptibility.

Key words psychological predictors, sleep, sport injury

Introduction

There are many definitions of injury in scientific resources. The most accepted injury definition according to Fuller et al. (2006) is "any physical complaint sustained by a player that results from a football match or football training, irrespective of the need for medical attention or time loss from football activities" (Fuller et al., 2006, p. 193). Injuries can be collected under two main titles, namely severity of injuries, and existence mechanism of injuries. Injury severities are classified into four categories: slight (absence from practise between one to three days), minor (absence from practise for more than three days but for less than one week), moderate (absence from

training or matches for more than one week but less than one month), and major (absence from practise more than one month) (Hägglund, Walden, Ekstrand, 2005a), existence mechanism of injuries are collected under two main subtitles like overuse and traumatic injuries (Hägglund, Walden, Ekstrand, 2005b). Overuse injury means that players develop musculoskeletal pain without any known trauma or complication (e.g., tendinosis, shin splints, stress fractures, etc.), in spite of that, if the injury was caused by a single identifiable event, it was categorized as traumatic injury (Hägglund, Walden, Ekstrand, 2005a). Previous studies showed that traumatic injuries are seen more frequent than overuse injuries (Poulsen, Freund, Madsen, Sandvej, 1991; Brito et al., 2012), for this reason, understanding risk factors, and injury mechanisms are essential to develop effective preventive approaches against football injuries. In 1994, Meeuwisse created a multifactorial model to evaluate risk factors, and causation for sport injuries (Meeuwisse, 1994). In this model, a risk factor is defined as a factor related to the injury. According to the author, risk factors of athletic injuries are classified as internal and external or as intrinsic and extrinsic. Usually, there is just one difference between intrinsic (internal) and extrinsic (external) injury risk factors, where intrinsic risk factors refer to player specific factors, which are individual physical and psychosocial characteristics like the player's age, playing position, strength and flexibility, external injury risk factors can be defined as the factors which are dependent on the environmental conditions like equipment, weather, field conditions, surface types, rules etc. (Murphy, Connolly, Beynnon, 2002; Lysens et al., 1984; Meeuwisse, Bahr, 2009). Sleep disturbance and stress are two intrinsic injury risk factors which humanity has had to cope with since coming into existence. Stress is a highly complex structure consisting of many different factors. In their work, Andersen and Williams (1988) published a schema showing the effects of stress on players` injuries (Andersen, Williams, 1988). According to this schema, factors such as competitive trait anxiety, life stress, motivation, daily hassles,or previous injuries are characterized by a stress response and the risk of injury is increased or decreased according to this stress response. Like stress, sleep disturbance is another process that affects many other systems in the body (Medic, Wille, Hemels, 2017). It is concluded that sleep disturbance has an effect on injuries but this issue needs to be supported by further studies (Milewski et al., 2014). In the light of this information, in order to expand knowledge about relationships between some psychological injury risk factors and injury susceptibility, the aim of this current study is to test the effects of life stress, competitive trait anxiety, and sleep disturbance on injury susceptibility in football players.

Methods

Study design

At the beginning, 73 football players of two local clubs in Cologne participated in this study. Players who were injured during the study were included but players who had already injuries before the study period, who left their club during the study period, who joined to the club after 01.08.2019, and who had a job or a daily accident (e.g., vehicle accidents, falling from heights or slipping) were not included in the study. All injuries were recorded by team a of physiotherapists. Six players were excluded because they did not meet the study criteria. 67 male football players (Goalkeepers not included) took part voluntarily in this experiment in the season. The players had three training sessions a week (on the pitch) and, in addition to weekly normal training sessions, they played one game at the end of the week. Written informed consent was obtained from every participant before commencing the experiment. The analysed data included level of formal education, age, height, working hours and training time. The mean age of players was 21.09 ±2.69, an average height of 181 cm ±6.111, a training time of approximately 8 ±3.464 hours, and working time of 15 ±16.385 hours a week. The study was carried out in accordance with the

Helsinki Declaration of 1975 and was approved by the Institutional Review Board of the local university. To analyse the effects of life stress, competitive trait anxiety, and sleep disturbance on injury susceptibility the last four months of each player were considered (August–November 2019).

Data collection

Holmes-Rahe Life Stress Scale

Holmes-Rahe life stress scale is used to measure life stress level (Noone, 2017) The scale consists of 43 items. Each item has different score for stress, more marked items mean a higher score. The higher score, the more likely the player would become ill. After the assessment finished, the results are classified in three categories. If the score is ≤150, players have low risk of illness, scores between 151 and 299 are moderate risk of illness with 50% chances and if the score is ≥300, there is high (80%) chance of getting ill. Gerst et al. (1978) tested the reliability of the Holmes-Rahe life stress scale, and found that rank ordering remained extremely consistent both for healthy adults (r = 0.96 – 0.89) and patients (r = 0.91 to 0.70) (Gerst, Grant, Yager, Sweetwood, 1978).

Sport Competition Anxiety Test (SCAT)

SCAT is used to measure competition trait anxiety (Brand, Hanekom, Scheepers, 1988). The scale consists of 15 statements, the statements were answered on a three-point scale (often, sometimes, hardly ever) and a summary score ranging from 10 (low competitive trait anxiety) to 30 (high competitive trait anxiety). A score of less than 17 indicates a low level of anxiety, 17 to 24 an average level of anxiety, and more than 24 a high level of anxiety. The test-retest reliability of the SCAT has been documented to range from r = 0.73 – 0.88 and an internal consistency or r = 0.95 – 0.97 (Martens, Vealey, Burton, 1990).

Pittsburgh Sleep Quality Index (PSQI)

PSQI is used to measure sleep disturbance (Buysse, Reynolds, Monk, Berman, Kupfer, 1988) PSQI consists of 19 self-rated questions and 5 questions rated by bed partner. Only self-rated questions are included in the scoring. The 19 self-rated items are grouped into seven component scores, each weighted equally on a 0–3 scale. The seven component scores are then summed to yield a global PSQI score, which has a range of 0–21; higher scores indicate worse sleep quality. The overall PSQI global score correlation coefficient for test – retest reliability is 0.87 (Backhaus, Junghanns, Broocks, Dieter, Hohagen, 2002).

Oslo Sports Trauma Research Centre Questionnaire (OSTRC)

OSTRC is used to measure players' injuries (Clarsen, Ronsen, Myklebust, Florens, Bahr, 2012). Using this scale all types of health problems in sport can be evaluated; acute injuries, overuse injuries and illnesses can be documented sensitively and validly. Cronbach's α value of OSTRC is 0.92, this questionnaire has an interclass correlation coefficient 0.91 (Hirschmüller et al., 2017).

All these questionnaires were translated into German and the responsibility for professional conduct during testing was assumed by a trained expert.

Statistical Methods

Data were statistically analysed using SPSS version 25. The significance level was set at $p < 0.05$. Descriptive data is generally presented for quantitative variables (e.g., age, height, working hours, training time) as mean values with *SD* or 95% *CI*. The relationships between groups were tested by multiple linear regression analysis, using the

backward elimination method. Multiple linear regression is a statistical technique that uses several independent variables (life stress, competitive trait anxiety and sleep disturbance) to predict the outcome of a dependent variable (injury susceptibility).

Results

Injury severity and anatomical location of Injuries

As shown in Table 1, 51 injuries were reported, 16 players did not sustain any injuries during the examination period. Of the 51 injuries, 43.1% were slight, 27.5% minor, 7.8% moderate and 21.6% of the injuries were major. Concerning this descriptive data, while 53.7% (36/67) of the players stayed away from the football field for at least one week, about 23.8% (16/67) of them did not have any injury during this four months' period. Most injuries were located at the lower extremities (96–98%). The most common locations of injury among players are the knee (39.5%), the foot/toes (19.7%), the hip/groin (15.7%) and the ankle (9.8%) respectively. Upper extremity injuries were rarely observed in this group of players. Shoulder, lower back, or thoracic spine injuries were not seen, the incidence rate of injuries to the head/face were 1–2%.

Table 1. Injury location and severity in football players

	Injuries	Slight	Minor	Moderate	Major
Head/face/neck	1 (1.8)	1 (4.5)	–	–	–
Hip/groin	8 (15.7)	2 (9)	3 (21.4)	3 (75)	–
Thigh	4 (7.8)	–	2 (14.2)	1 (25)	1 (9.1)
Knee	20 (39.5)	6 (27.3)	8 (57.2)	–	6 (54.5)
Lower leg	1 (1.8)	–	1 (7.2)	–	–
Ankle	5 (9.8)	4 (18.2)	–	–	1 (9.1)
Foot/toes	10 (19.7)	8 (36.5)	–	–	2 (18.2)
Other	2 (3.9)	1 (4.5)	–	–	1 (9.1)
Total	51 (100)	22 (100)	14 (100)	4 (100)	11 (100)

Values in parenthesis are percentages. Approximation of the percentages has been made to equal 100%.

Outcome measure

As a finding of the survey results 14.9% of the athletes rated their sleep quality as very good, 65.7% of them rated their sleep quality as fairly good and 19.4% rated it as bad and very bad. The average sleep quality index score of injured football players was 7.02 (*SD* = 1.57), uninjured players have 6.90 (*SD* = 1.74). While the average stress score of the injured players was about 95.15 (*SD* = 79), the average stress score of the uninjured players was 36.80 (*SD* = 22.8) and finally, the average competitive anxiety test scores of the injured and uninjured players were 16.43 (*SD* = 3.56), 17.6 (*SD* = 4.01) respectively (Figure 1).

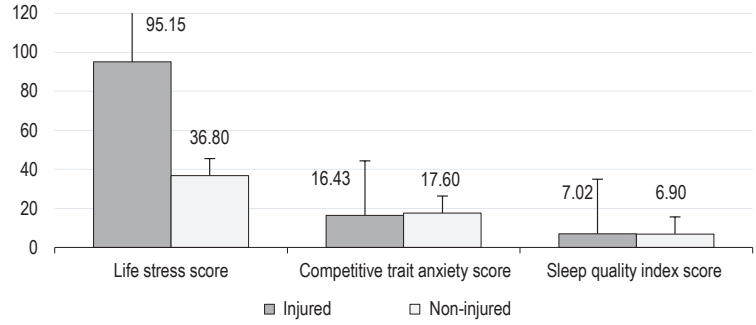

Figure 1. The comparison of life stress score, competitive trait anxiety, sleep duration between injured and uninjured players

The multiple linear regression analysis with backward elimination showed that life stress, competitive trait anxiety, and sleep disturbance could explain 13.3% of the total variance (R^2_{Adj} = 0.133, F (3.63) = 3.220, $p < 0.05$). The result of regression analysis indicated that life stress has an influence on injury susceptibility ($p < 0.05$; T = 2.731), whilst competitive trait anxiety (p = *0*.162; T = 1.414), and sleep duration (p = 0.125; T = 1.554) were not significant predictors of injury susceptibility.

Discussion

The aim of the study was to identify the effect of life stress, competitive trait anxiety, and sleep disturbance on injury susceptibility. The most significant finding in the present study was that there is a positive correlation between life stress and injury susceptibility, in other words, a high stress level causes an increased injury susceptibility among adult male football players. However, there is no correlation between competitive trait anxiety, sleep disturbance and injury susceptibility.

The effect of life stress on football injury susceptibility

While some studies have shown that athletes with high life stress have a high injury risk (Galambos, Terry, Moyle, Locke, 2005; Johnson, Ivarsson, 2009; Petrie, 1992). Ivarsson and Johnson (2010) found that there is no significant relationship between life stress and injury susceptibility (Ivarsson, Johnson, 2010). The current study shows that injured athletes had a significantly higher life stress score in comparison to uninjured players. The average life stress score is 82.09 (*SD* = 74.398), which means that players have relatively low life stress, despite the players' low life stress score, life stress has an effect on injury susceptibility *(p* < 0.05). This result indicates that life stress has more impact than it would appear. The regression analysis showed that the life stress variable could explain 6% of the total variance of injury occurrence, which means the life stress variable explains only one of about 17 injuries; this means, injury occurrence could also be influenced by several other internal or external injury factors. It should not be forgotten that there were a few players who had a higher life stress score than others which were proved by the high standard deviation of the stress score of the injured players (95.15 (*SD* = 79)), from this point of view, the homogeneity of group should be considered by future research.

The effect of competitive trait anxiety on football injury

Previous studies have found that there is a positive correlation between competitive trait anxiety and sport injuries (Song, Long, Jiao, 2017; Lavallee, Flint, 1996). There is only one study that showed a weak correlation between these two variables (Seidi, Rajabi, Daneshmandi, Fadaee, 2014). In this study, it was observed that competitive trait anxiety has no effect on players' injuries. The average competitive anxiety score was 16.79 (*SD = 3.77*). This score belonged to the first group which shows that their competitive anxiety level is low. When examining the relationship between anxiety and players' injuries, the low anxiety level of athletes limits our deduction while explaining the relationship between the competitive trait anxiety and the athlete's injury. In other words, if it has come up with a clearer explanation, the reason is not known why the athletes did or did not sustain less injury during the study period, whether there was no anxiety effect on athlete injury or whether the anxiety score of our participants was already low. For this reason, the relationship between anxiety and athlete injury should be tested more specifically with a wider group of players and a higher score.

The effect of sleep disturbance on football injury

Stimulation of protein degradation is increased by sleep disturbance, which affects protein synthesis, and the impairment in protein synthesis causes muscular atrophy and decelerates the recovery of athletes (Dattilo et al., 2011), for this reason, sleep plays an important role regarding performance and recovery of athletes (Bonnar, Bartel, Kakoschke, Lang, 2018). The average nocturnal sleep duration is 6.7 hours during the weekdays and on weekends is 7.4 hours (Goel, Rao, Durmer, Dinges, 2009). There are some studies, which have shown a positive correlation between sleep disturbance and sport injury (Gao, Dwivedi, Milewski, Cruz, 2019; Milewski et al., 2014). In the current study, sleep quality index score is low, it means that players have a good sleep quality. Sleep duration of players is about 7 hours, this is normal for athletes aged between 18 and 25. Although the result was found that there is no effect of sleep disturbance on injury susceptibility, this result isn't clear enough. Due to low sleep quality index score and normal sleep duration the effect of sleep disturbance on injury susceptibility is not known, it is also not known whether there was no effect of sleep disturbance on athletes' injury or the sleep quality index score was already low. For this reason, another study would need to be conducted with a wider group of players whose sleep duration and sleep quality index score are different from the average.

Conclusion

The present study concludes that there is a positive correlation between life stress and athletes' injuries, but competitive trait anxiety and sleep disturbance had no effect on injury susceptibility. It is important to know that the group size and short time period limit the interpretation of the statistical results. Therefore, further studies should be performed with a larger experimental group with long time in order to have more appropriate and interpretable results. In addition to this, in order to achieve more realistic outcomes a study could be designed in the light of previous studies based on one experimental and one control group.

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