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PROFILE OF MUSCULAR STRENGTH, ENDURANCE, AND MOVEMENT PATTERNS IN RECREATIONAL INDIVIDUALS PERFORMING TARGETED STRENGTH TRAINING

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Abstract This study aimed to assess muscular strength, endurance, and movement pattern quality in adults engaged in recreational, targeted strength training compared to physically active individuals without a specific strength focus. A total of 60 participants were included: 34 in the experimental group (17 men, 17 women) and 26 in the control group (13 men, 13 women). All subjects completed the Functional Movement Screen (FMS) to evaluate movement quality. Muscular strength and endurance were assessed using four tests based on ACSM's Guidelines for Exercise Testing and Prescription (11th ed.): Handgrip Strength, Bench Press Ratio, Leg Press Ratio, and Push-Up Test. In the strength-training group, 79.4% scored ≥18 on the FMS (vs 61.5% in controls), with no scores <14 (vs 3.8%). In the Handgrip Test, 63% scored at or above the 50th percentile (vs 58%). The experimental group more often achieved "Good" or higher classifications in the bench press and push-up tests. Notably, 45% scored "Very Good" or "Excellent" in push-ups (vs 19% in controls). Findings suggest that regular, targeted strength training contributes to higher levels of muscular strength, endurance, and movement quality, potentially reducing injury risk and enhancing functional performance.

Key words: functional fitness, strength training, Functional Movement Screen, muscle strength, muscle endurance

Introduction

Muscular strength and endurance constitute key components of physical fitness and are essential indicators of human health and functionality (ACSM, 2021). From a physiological perspective, muscular strength is defined as the ability of a muscle or muscle group to exert maximal force against resistance in a single contraction (Kenney et al., 2019). It can be assessed under static (isometric) or dynamic (concentric–eccentric) conditions using tests such as the one-repetition maximum (1-RM) or the Handgrip Strength Test. Muscular endurance, in contrast, refers to the ability of muscles to perform repeated contractions or sustain a given level of tension over time without loss of movement quality (Schoenfeld et al., 2016).

Regular physical activity, particularly resistance training, induces a range of physiological adaptations leading to increases in strength, endurance, postural stability, and overall functional fitness (Górski, 2019; Plowman & Smith, 2014). Recent research confirms that even in recreationally trained individuals, systematic resistance training produces significant neuromotor adaptations and improvements in Functional Movement Screen (FMS) scores, particularly in the domains of stability and movement control (İribalcı et al., 2024).

Functional fitness is defined as the ability to perform daily tasks efficiently, safely, and independently (Gieroba, 2019). The literature indicates that resistance training is a crucial element in injury prevention, quality-of-life improvement, and the maintenance of functional capacity across age groups (ACSM, 2021; Schoenfeld et al., 2017). One of the most recognized tools for assessing movement quality and identifying functional deficits is the Functional Movement Screen (FMS). It consists of seven movement tasks that evaluate mobility, stability, and neuromuscular coordination, and is widely used to assess injury risk and movement pattern quality (Cook et al., 2014).

Studies have shown that regular resistance and stabilization training can improve FMS scores, particularly when programs include complex functional movements engaging the core musculature (Behm et al., 2010; Okada et al., 2011). Similarly, Wang et al. (2024) demonstrated that functional resistance training significantly enhances not only muscular strength but also movement quality measured by FMS among wushu athletes, underscoring the universality of the FMS tool across active populations.

The practical application of the FMS test was presented in the study “The Effects of Strength and Conditioning on Functional Movement Screen™ Scores in Secondary School Basketball” (Dexter et al., 2020), where significant improvements in FMS performance were observed among young basketball players following a structured strength and conditioning program. These findings confirm the FMS test’s utility for monitoring functional changes in physically active populations.

The present study utilized four muscular strength and endurance tests (Handgrip Strength Test, Bench Press Weight Ratio, Leg Press Weight Ratio, and Push-Up Test), following the guidelines of the American College of Sports Medicine (ACSM, 2021). The ACSM is a globally recognized authority in exercise science and sports medicine, known for developing evidence-based standards and protocols. Since its founding in 1954, the organization has regularly published and updated guidelines for assessing physical fitness, covering key components such as cardiorespiratory endurance, muscular strength, muscular endurance, and flexibility. These recommendations are widely applied in sports medicine and physiotherapy practice.

A practical example of these standards is the study “Development of a Standard Push-up Scale for College-Aged Females” (Lang et al., 2022), which established normative data for the push-up test among university-aged women based on ACSM recommendations. The results confirmed the diagnostic value of simple field tests for assessing muscular endurance and functional fitness.

Comparable findings were reported by Yilmaz et al. (2024), who compared recreationally active and sedentary individuals, confirming a significant association between regular exercise participation, higher FMS scores, and improved relative strength parameters.

Previous analyses indicate that resistance training leads to favorable neuromuscular adaptations by enhancing motor unit recruitment efficiency and the ability to generate force (Suchomel et al., 2018). Most research on these phenomena, however, has focused on elite athletes or clinical populations, with relatively few studies addressing recreationally trained adults—among whom significant strength-endurance and functional adaptations also occur (Peterson et al., 2011). This research gap has been highlighted in recent publications (İribalcı et al., 2024; Yilmaz et al., 2024), which emphasize the need for integrated assessment of strength, endurance, and movement quality in recreationally active adults. This gap limits understanding of how resistance training affects comprehensive movement performance in this population. The originality of the present study lies in its integrated diagnostic approach combining the assessment of muscular strength, endurance, and movement quality (FMS) within a single population. This design enables simultaneous analysis of strength-endurance and functional components, allowing for a more complete evaluation of recreational training effects. In the context of contemporary sports medicine and exercise physiology, a holistic approach to analyzing strength, endurance, and movement functionality is a key aspect of assessing training effectiveness, planning injury prevention strategies, and individualizing exercise programs (ACSM, 2021; Suchomel et al., 2018). Therefore, the aim of the present study was to conduct a comprehensive evaluation of muscular strength, endurance, and functional fitness in adults regularly participating in resistance training compared with those engaged in general physical activity not focused on strength development.

Methods

A total of 60 participants took part in the study, including 34 individuals in the experimental group (EG) and 26 in the control group (CG). Both groups maintained an equal gender distribution (50% women, 50% men). Participants' ages ranged from 18 to 40 years (M=24.3; SD=4.8). The majority of participants held a higher education degree (over 50% in both groups) and resided in large urban areas with populations exceeding 500,000 inhabitants (approximately 77%). Relationship status was evenly distributed, with similar proportions of single and partnered individuals.

The study was conducted in compliance with the Declaration of Helsinki and was approved by the Bioethics Committee of the Karol Marcinkowski Medical University, Poznań, Poland (No.163/125).

All participants met the inclusion criteria: they were healthy adults without contraindications to physical exercise and reported no injuries within the previous six months. Each participant engaged in regular physical activity 3–4 times per week, with training sessions lasting between 1 and 2 hours.

Exclusion criteria included: the use of medications affecting the nervous or muscular system, metabolic disorders, and a lack of prior training experience. The experimental group (EG) consisted of individuals who had been consistently engaged in strength training for at least 12 months (3–4 sessions per week, each lasting 60–90 minutes). The control group (CG) included participants who practiced other forms of recreational physical activity, such as swimming, cycling, yoga, Pilates, or brisk walking – with the same frequency and duration. Demographic and lifestyle data were collected using a custom-designed questionnaire containing standard sociodemographic items to characterize the participants. A detailed summary of participant characteristics is presented in Table 1.

Table 1. Characteristics of the Experimental and Control Groups

	Experimental group n (%)	Control group n (%)
Sex		
– Men	17 (50%)	13 (50%)
– Women	17 (50%)	13 (50%)
Age		
– 18–26 years old	17 (50%)	11 (42.3%)
– 27–35 years old	7 (20.6%)	6 (23.1%)
– >35 years old	10 (29.4%)	9 (34.6%)
Education		
– Higher education	22 (64.7%)	15 (57.7%)
– Secondary education	9 (26.5%)	6 (23.1%)
– Vocational education	3 (8.8%)	5 (19.2%)
Place of residence		
– City >500,000 inhabitants	26 (76.5%)	20 (76.9%)
– City 50,000–100,000 inhabitants	6 (17.6%)	–
– Village	2 (5.9%)	6 (23.1%)
Relationship status		
– Single	17 (50%)	9 (34.6%)
– In a relationship	17 (50%)	17 (65.4%)
Number of training sessions per week	3–4: 34 (100%)	3–4: 26 (100%)
Duration of a single training session	1–2 hours: 34 (100%)	1–2 hours: 26 (100%)

The study was conducted in July and August 2024 at the Fitness Point Training Center in Poznań, Poland, which was equipped with professional resistance training facilities. Participants were informed about the study procedures and were instructed to refrain from strenuous exercise, caffeine, and alcohol consumption for 24 hours prior to testing.

Before testing, each participant attended a familiarization session to become acquainted with the maximal strength (1-RM) and FMS testing procedures. On the test day, all participants performed a standardized warm-up, consisting of 5 minutes of ergometer cycling, 5 minutes of dynamic stretching, and three sets of light-load exercises.

The order of tests was identical for all participants:

a) Functional Movement Screen (FMS)
b) Handgrip Strength Test
c) Bench Press Weight Ratio
d) Leg Press Weight Ratio
e) Push-Up Test
f) Rest intervals between tests ranged from 5 to 10 minutes, and between attempts within a single test, 2 to 3 minutes. All measurements were performed by the same examiner — a certified strength and conditioning specialist.
g) Resistance training program followed by participants in the EG group was performed 3–4 times per week for a minimum of 12 months, following the principles of progressive overload (Suchomel et al., 2018; Schoenfeld et al., 2021). The training program included 6–8 multi-joint exercises targeting major muscle groups (e.g., squat, deadlift, bench press, bent-over row, overhead press, pull-up), performed in 3–5 sets of 6–12 repetitions at 65–85% of 1-RM. Rest intervals between sets were 60–120 seconds. The program

followed an undulating periodization model, with cyclical adjustments in training volume and intensity every 4–6 weeks. The goal of the program was to develop maximal strength and muscular endurance, without specific preparation for competitive performance. The control group (CG) did not participate in resistance training and engaged only in recreational and health-oriented physical activities, such as swimming, cycling, yoga, Pilates, or brisk walking, with similar frequency and duration.

The testing protocol included the following components:

a) Functional Movement Screen (FMS):

The FMS consisted of seven movement tasks: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise, trunk stability push-up, and rotary stability. Each task was scored on a 0–3 scale (Cook et al., 2014). Score interpretation:

– 18–21 points – low injury risk
– 14–17 points – moderate risk (25–35%)
– <14 points – high risk (up to 50%)

b) Handgrip Strength Test:

The test was conducted according to ACSM (2021) guidelines. Isometric grip strength was measured using a calibrated hand dynamometer. Participants performed three trials for each hand while seated, with the elbow flexed at 90° and without arm support. The highest value was recorded for analysis.

c) Bench Press Weight Ratio:

Maximal upper-body strength was assessed using the actual 1-RM method following ACSM (2021) recommendations. The load was progressively increased by 2.5–5% of body mass until technical failure occurred. The result was expressed as the ratio of lifted weight to body mass.

d) Leg Press Weight Ratio:

The test was conducted according to ACSM (2021) procedures using a Technogym 45° Leg Press machine. The maximum single-repetition load was determined, and results were expressed as the ratio of lifted weight to body mass.

e) Push-Up Test:

The test followed ACSM (2021) standards. Participants performed the maximum number of push-ups at a tempo of 40 beats per minute, paced by a metronome. The test was terminated when the participant failed to maintain full elbow extension or lost rhythm. The outcome was the number of correctly performed repetitions.

Data Analysis

Upon completion of all testing procedures, the collected data were carefully recorded and anonymized. Descriptive statistics were calculated, including arithmetic means, standard deviations, and score ranges. To evaluate differences between the experimental and control groups, independent samples t-tests were applied, with the level of statistical significance set at $p<0.05$. All statistical analyses were performed using the Statistica software package.

Results

The mean total Functional Movement Screen (FMS) score was 18.71±2.27 points in the experimental group and 18.58±3.61 points in the control group. Median and mode values were similar to the means, and the range of scores spanned 14–21 points. The coefficient of variation (Vr) indicated moderate within-group variability (Vr_EG=12.1%; Vr_CG=19.4%). The vast majority of participants achieved a score of ≥18 points, indicating a low risk of injury (EG: men 76%, women 82%; CG: men 69%, women 54%). In the control group, a score below 14 points was observed in only one participant (8%).

No statistically significant differences between groups were found (t(58)=0.16;=0.87), and the Cohen's d=0.04 indicated a negligible effect size. The two-way ANOVA (2×2: group × sex) revealed no significant interaction effects (F(1,56)=0.44; p=0.51), indicating that the quality of movement patterns did not differ significantly between groups or across sexes.

In the analysis of individual FMS components, slightly higher mean scores were recorded in the experimental group for FMS1 (deep squat), FMS3 (in-line lunge), and FMS5 (active straight leg raise). However, none of these differences reached statistical significance. Detailed results are presented in Table 2.

Table 2. Results of the Functional Movement Screen (FMS) Test

Score range	EG Men n (%)	EG Women n (%)	CG Men n (%)	CG Women n (%)
<14 pkt	0 (0%)	0 (0%)	1 (8%)	0 (0%)
14–17 pkt	4 (24%)	3 (18%)	3 (23%)	6 (46%)
≥18 pkt	13 (76%)	14 (82%)	9 (69%)	7 (54%)

Table 3 presents the average values obtained in the strength and endurance tests.

Table 3. Results of Strength and Endurance Tests

Test	EG (M±SD)	CG (M±SD)	Cohen's d	p
Handgrip [kg]	39,56±12,76	37,81±8,56	0,16	0,41
Bench Press Ratio	0,905±0,117	0,848±0,116	0,49	0,09
Leg Press Ratio	1,70±0,12	1,61±0,12	0,75	0,06
Push-Up [n]	20,97±12,92	14,50±6,87	0,60	<0,05

The medians and modes for all tests were close to the mean values, confirming the normality of distributions. The observed value ranges were as follows:

a) Handgrip Strength: 21–60 kg
b) Bench Press Ratio: 0.68–1.08
c) Leg Press Ratio: 1.45–1.85
d) Push-Up Test: 5–45 repetitions
e) The coefficients of variation (Vr) indicated greater individual variability in endurance tests (Push-Up: Vr=61.6%) than in relative strength tests (Vr=7–14%). A statistically significant difference between groups was observed only in the Push-Up Test (p<0.05), with a moderate effect size (d=0.60). This result confirms the superiority of the experimental group in upper-body muscular endurance. In the Bench Press and Leg Press tests, tendencies favoring the experimental group were also noted (d=0.49–0.75), although these did not reach statistical significance – likely due to the moderate sample size and within-group variability. The two-way ANOVA (group × sex) revealed a significant main effect of group for the Push-Up Test (F(1,56)=5.12; p=0.027), whereas neither sex effects nor interaction effects were found (p>0.05).

f) A Pearson correlation analysis was performed between the total FMS score and the strength and endurance tests (Handgrip, Bench Press, Leg Press, Push-Up). No statistically significant correlations were observed ($p>0.05$), although weak positive trends were identified — the strongest association occurred between FMS and Push-Up ($r=0.28$; $p=0.07$). This result suggests that better movement pattern quality may co-occur with greater muscular endurance, although it does not directly indicate maximal strength capacity. For the main variables (FMS, Bench Press Ratio, Leg Press Ratio, Push-Up Test), a post-hoc power analysis was conducted using G*Power 3.1.9.7 (Faul et al., 2009), assuming a medium effect size ($d=0.5$, $\alpha=0.05$, $n=60$). The obtained statistical power ($1-\beta$) was 0.83, indicating sufficient sensitivity of the tests and confirming the reliability of observed differences between groups.

Summary of findings:

a) FMS: No significant differences between groups; most participants demonstrated proper movement patterns (≥18 points).
b) Strength and endurance: Significant advantage of the experimental group in the Push-Up Test ($p<0.05$; $d=0.60$). Other differences were non-significant but favored EG.
c) ANOVA: Confirmed a significant main effect of group ($p<0.05$) without group × sex interaction.
d) Correlations: No significant associations between FMS and strength tests; the strongest trend was observed between FMS and Push-Up.
e) Power analysis: The obtained value of power=0.83 indicates adequate statistical sensitivity for the conducted analyses.

Discussion

The purpose of this study was to assess the levels of muscular strength, endurance, and movement pattern quality among adults engaged in structured strength training compared with physically active individuals not specifically focused on strength development. In line with the findings of Cook et al. (2014) and the principles of functional movement progression described by Zatsiorsky (2006), a well-designed resistance training program does not deteriorate movement quality.

The results of the present study confirm this assumption — despite higher training loads, the experimental group maintained a high level of movement quality as assessed by the Functional Movement Screen (FMS). The absence of significant differences between groups in FMS scores may suggest that regular physical activity — regardless of its form — contributes to maintaining effective motor control and movement stability. This observation aligns with findings reported by Fitton-Davies et al. (2022) and Dexter et al. (2020), who demonstrated that both resistance training and general recreational activity can enhance movement patterns and reduce asymmetries. Furthermore, Wang et al. (2025), in a randomized controlled trial, showed that long-term strength and functional training significantly improves motor control and trunk stability, which provides strong empirical support for the findings of the present study.

The analysis of strength tests revealed a superiority of the experimental group in upper-body muscular endurance (Push-Up Test). This finding corroborates previous evidence by Schoenfeld et al. (2016) and Suchomel et al. (2018), indicating that systematic resistance training leads to increases in both maximal strength and local muscular endurance. The underlying mechanisms include enhanced motor unit recruitment, improved contraction synchronization, and metabolic adaptations that increase resistance to fatigue (Zatsiorsky, 2006; Bompa &

Buzzichelli, 2022). Similar tendencies were observed by Maleki et al. (2025), who, in a meta-analysis, found that interventions combining strength and stabilization training significantly improve FMS scores, regardless of participants' training background. It is also worth noting that training adaptations in strength outcomes may differ between sexes — women typically show smaller gains in absolute strength but similar improvements in relative strength (Bishop et al., 2008; Roberts et al., 2020). Likewise, Khuyagbaatar et al. (2025) reported that prior resistance training experience is strongly correlated with movement quality and reduced overload risk, supporting the trends observed in the present study. However, the applied ANOVA analysis did not reveal significant group × sex interactions, which might be due to insufficient statistical power to capture subtle sex-related differences.

When interpreting the FMS outcomes, it should be emphasized that the absence of group differences does not imply a lack of training effect, but rather confirms that various forms of regular physical activity can yield comparable levels of motor competence when performed with proper technique. This interpretation aligns with earlier studies (Teyhen et al., 2012; Kiesel et al., 2007), which indicated that general physical activity and stabilization exercises are sufficient to maintain appropriate movement patterns in adults.

Several limitations should be considered when interpreting the results. The sample size was moderate (n=60), potentially reducing the statistical power to detect small group or sex differences. The study design was cross-sectional, precluding causal inferences about the relationship between training and changes in movement quality. The lack of randomization and absence of longitudinal follow-up limit the ability to assess the durability of observed effects.

Finally, no real injury data were collected, which prevents a direct conclusion that resistance training reduces injury risk – this should instead be interpreted as a potential preventive effect, requiring further prospective studies. Recent publications (Wang et al., 2025; Khuyagbaatar et al., 2025) also emphasize the necessity of such prospective research, particularly among recreationally active adult populations. Practical conclusions:

a) regular resistance training may enhance upper-body muscular endurance and help maintain high-quality movement patterns;
b) the absence of significant FMS differences between groups suggests that various forms of physical activity can effectively maintain functional mobility and stability;
c) the findings highlight the importance of balancing strength and functional training components in recreational and health-oriented programs;
d) the use of the FMS in evaluating physically active adults may serve as a useful tool for monitoring movement quality and identifying potential overload risks;
e) for coaches and physiotherapists, these results may support the individualization of training loads while maintaining an emphasis on safety and movement quality;
f) future research should increase sample size, apply randomized participant selection, and include prospective observation to confirm the long-term effects of resistance training on injury risk and functional adaptations.

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