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PHYSICAL ACTIVITY AND FUNCTIONAL FITNESS OF STUDENTS

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Aktywność fizyczna a poziom sprawności funkcjonalnej studentów

Streszczenie

Badania wskazują, że 45% Europejczyków nie uczestniczy w aktywności fizycznej, a niezdrowe nawyki związane ze stylem życia, nabyte podczas lat uniwersyteckich, mogą utrzymywać się w życiu dorosłym. Podejmowanie aktywności fizycznej wiąże się z wieloma korzyściami, ale także zwiększa prawdopodobieństwo przeciążeń i urazów. Wykorzystanie skutecznych metod predykcji urazów umożliwia przesiewowe badanie populacji, przyczyniając się do zwiększenia świadomości podczas stosowania aktywności fizycznej, ograniczenia występowania urazów, a w konsekwencji – wpływania na stan zdrowia społeczeństwa. Celem niniejszej pracy jest zbadanie związku między poziomem aktywności fizycznej a sprawnością funkcjonalną studentów oraz ocena ryzyka urazów związanych z podejmowaną aktywnością fizyczną. Do badania włączono 114 studentów (44 kobiety i 70 mężczyzn) w wieku od 19 do 23 lat. Przeprowadzono badanie poziomu aktywności fizycznej (International Physical Activity Questionnaire – IPAQ) oraz test sprawności funkcjonalnej – Functional Movement Screen (FMS). U większości badanych wzorce ruchowe są zaburzone, ponieważ występują asymetrie i kompensacje funkcjonalne, które wymagają podjęcia działań profilaktycznych oraz ćwiczeń kompensujących. Ryzyko urazu, szacowane na podstawie oceny FMS, wynosi od 25 do 35%. Studenci, w porównaniu ze studentkami, wyróżniają się przeciętnie lepszymi wynikami w próbach testu, ujętych jako wzorce mobilności (WM); charakteryzują się także lep-

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szymi wynikami we wzorcach stabilności (WS). Obserwuje się istotne związki między intensywną aktywnością fizyczną a wzorcami stabilizacji bocznej miednicy, tułowia i bioder (FMS 2), stabilizacją tułowia (FMS 6) oraz wzorcami stabilności (WS). Całkowita aktywność fizyczna wykazuje istotną dodatnią korelację z próbą ugięcia ramion w podporze.

Słowa kluczowe: aktywność fizyczna; sprawność funkcjonalna; FMS; studenci.

Abstract

Research demonstrates that 45% of Europeans do not participate in physical activity, and unhealthy lifestyle habits acquired during college years can persist into adulthood. Undertaking physical activity brings many benefits but also a greater likelihood of overload and injuries. The use of effective injury prediction methods enables the screening of the population, contributing to its greater awareness when engaging in physical activity, reducing the occurrence of injuries, and, consequently, influencing the health of society. The aim of this study is to examine the relationship between the level of physical activity and the functional fitness of students and to assess the risk of injuries related to physical activity. A total of 114 students (44 women and 70 men) aged 19-23 took part in the research. A physical activity level test (International Physical Activity Questionnaire-IPAQ) and a Functional Movement Screen (FMS) test were performed. In most subjects, movement patterns are disturbed due to asymmetries and functional compensations that require preventive measures and compensatory exercises. The risk of injury, estimated based on the FMS assessment, is 25-35%. Compared to female students, male students achieve, on average, better results in test samples classified as mobility patterns (MP); male students have better results in stability patterns (SP). Significant relationships are observed between intense physical activity and lateral stabilization patterns of the pelvis, trunk, and hips (FMS 2), trunk stabilization (FMS 6), and stability patterns (SP). Moreover, total physical activity shows a significant positive correlation with the trunk stability push-up.

Keywords: physical activity; functional fitness; FMS; students.

Introduction

The importance of regular physical activity (PA) for optimal functioning of humans is a fact confirmed by extensive scientific evidence and recommendations issued by organizations and scientific societies (Luan et al., 2019; WHO, 2020). The level of physical activity of modern human beings is a resultant of lifestyle, particularly evident in attitudes towards active and passive leisure activities. Research on sports and physical activity of Europeans shows that 45% of them do not engage in physical activity. Young persons aged 15–24 (54%) are the most likely to participate in sports with some regularity. Those aged over 20 who continue their education are particularly active (European Commission, 2022). A review of studies on physical activity and physical fitness of university students indicates that it is satisfactory (Kljajevic et al., 2022). Among other things, studies often use the International Physical Activity Questionnaire (IPAQ) to assess physical activity (Osipov et al., 2020; Pituk et al., 2019). To assess the fitness level of students, authoritative and standardized fitness test batteries are most often used (Griban et. al., 2020; Mitrović et al., 2016; Vrublevskiy & Asienkiewicz, 2018) or, less frequently, VO2max measurement on a treadmill or bicycle ergometer (Kang et. al. 2021; Shimamoto et. al., 2021). A decline in physical activity levels is observed during the transition of young adults into early adulthood, with the steepest decline at the start of college, most dramatically when respondents begin their studies (Kwan et al., 2012; Sigmundova et al., 2013). Bray and Born (2004) emphasise the fact that one third of active secondary school students became insufficiently active after transitioning to university life. Observation of the determinants of students' health behaviours in the field of PA indicates that half of them are physically inactive and activities promoting change bring about moderate effects (Keating, 2005). The period of studies involves the transfer of a young person from the family home and the school desk to the conditions of university education, leading to independence in organizing the day, changing the lifestyle and managing free time (Deliens et al., 2015; Wang et al., 2015). Research conclusions provided by Sweileh (2023) suggest that unhealthy lifestyle habits acquired during university years may persist into adulthood, especially since this is the last moment in which young people are involved in a compulsory study programme, including sports activities, with a wide range of sports and recreational activities as well as access to university sports facilities.

Undertaking physical activity is associated with numerous benefits, but also a greater likelihood of overload and injuries in young persons engaging in recreational and sports activities (Gage et al., 2012; Wojtkowski et al., 2014; Złotkowska et al., 2015). In order to assess the risk of injury while practising PA, several tests have been developed to target movement by function, which also enables preventive measures (Clifton et al., 2016; Emery & Pasanen, 2019). One of the most popular functional tests assessing the risk of injuries is the Functional Movement Screen (FMS) (Cook et al., 2006a, 2006b). It enables a comprehensive analysis of the quality of basic movement patterns, assessment of the risk of injury, and identification of the existence of limitations and asymmetries that may not be observed in other standard anthropometric and physiological assessments. It is used in sports and physiotherapeutic practice as it offers the possibility of quick, simple and inexpensive assessment using just 7 movement tasks involving basic movement patterns in the area of stability, mobility and motor control (Cook et al., 2014a, 2014b). Correct movement patterns are a manifestation of the proper function of the respective body parts treated as a whole as a biokinematic chain. Disorders in one of the body parts manifest themselves in the progressive dysfunction of movement and compensation, leading to incorrect functioning of individual parts of the body when undertaking PA, which may, in turn, result in greater susceptibility to injuries. (Chorba et al., 2010; Cook et al., 2006a, 2006b; Garrison et al., 2015). The assessment of the effectiveness of the use of FMS functional assessment combined with a synthesis of the scientific literature based on the review of 34 topical articles indicate FMS as a tool for predicting sports results, assessing the risk of injuries and assessing the effectiveness in designing training programs. The conclusions from the studies in question indicate that most scientific reports list FMS as a reliable tool to prevent injuries in people practising PA, provided the assessment is carried out by an experienced assessor (>100 attempts) (Kraus et al., 2014). Many of the available studies focus on assessing the FMS of a population of athletes, so a meta-analysis from published data on a group of children and adolescents indicating gender- and age-related differences in functional test scores, as well as the clearly negative relationship between body mass index and physical fitness, provides normative reference values for physical activity and physical education practitioners (O'Brien et. al., 2022).

The university period is an important and critical moment in the lives of young people (Manzheley & Cherniakova, 2014), while creating a favourable environment shaping health and forming proper habits during this period constitutes the basic task of educational institutions (Geidne et al., 2013; Wright et al., 2013). Trudeau and Shephard (2008) believe that educational institutions should organize a wide range of activities contributing to the improvement of the health culture of students and shaping a healthy lifestyle in the later years of their lives. Kljajevic et al. (2022) state that universities are ideal environments to promote physical fitness and activity. It is particularly important to develop an optimal fitness programme (Randall et al., 2009) or encourage regular physical activity as the main way to instill a healthy lifestyle in students (Bozhkova et al., 2017; Forshee et al., 2004). On the other hand, the use of effective injury prediction methods involving the assessment of movement patterns in the areas of stability, mobility and motor control, enables the screening of populations, contributing to their greater awareness in the use of physical activity, reducing the incidence of injury and, consequently, influencing health. There is a lack of studies of student populations following this approach to the assessment of physical fitness.

Therefore, the purpose of this study is to assess the level of physical activity and the level of functional fitness of the male and female students surveyed and to examine the relationship between the level of physical activity and the functional fitness, with the differences between genders in mind, as well as to assess the risk of injuries related to physical activity. It also aims to identify potential movement pattern disorders which can be the basis for recommending preventive actions and compensatory activities that may contribute to improving the quality of life of students and minimizing the risk of injuries in the future.

Material and research methods

Study Design

The research was conducted in 2019 among 114 students (44 women = 38.6% and 70 men = 61.4%) of the University of Zielona Góra (Poland). All students agreed to participate in the research voluntarily and were informed about its purpose and the anonymity of the results. The research concept was approved by the Bioethics Committee of the Regional Medical Council in Zielona Góra (No. 07/118/2019, Zielona Góra, Poland).

Measures/Inventories

As part of the research, a survey was conducted among students using the International Physical Activity Questionnaire (IPAQ) – its shortened Polish version, while the Functional Movement Screen (FMS) test was used to determine the level of functional fitness of the subjects. In addition, a survey was conducted among the students (research particulars), which determined the respondents' place of residence, self-assessment of health and declared level of physical activity. Basic somatic measurements (body height and body weight) were also performed.

Physical Activity Questionnaire (IPAQ) – its shortened Polish version including 7 questions regarding all types of physical activity related to everyday life, work and recreation (Biernat et al., 2007). Activities performed at work, at home and in its surroundings, in moving from place to place and in free time devoted to recreation, exercise or sports were examined. Information was collected on time spent sitting, walking and time spent on physical activity – intense and moderate. The questionnaire only takes into account activities lasting at least 10 minutes (without a break). Each type of physical activity can be expressed in MET-min/week units by multiplying the coefficient assigned to such an activity by the number of days it is performed per week and its duration in minutes per day. For the short version of the questionnaire, there are three types of physical activity (physical exercise): walking, moderate activity, intense activity. Based on the results using (IPAQ), those tested can be classified according to their level of physical activity. Three levels are distinguished: high, sufficient, insufficient (Biernat et al., 2007).

Functional Movement Screen (FMS) test consists of 7 movement tasks. Each movement task is graded on a scale of 0-3 points. Each examinee has three attempts to perform each exercise and the best result is assessed (Cook et al., 2014a, 2014b). The maximum number of points that can be scored in the test is 21 points. The results are classified into three ranges (Kiesel et al., 2007). The evaluation criteria and classification of the FMS test are shown in Table 1. The test trials can be divided into three types of movement patterns: global, mobility and stability. The global patterns (GP) include the following tests: *deep squat, hurdle step, in-line lunge*. Mobility patterns (MP) include: *shoulder mobility, active straight leg raise*. For stability patterns (SP) *trunk stability push up, rotational stability*.

Table 1
Functional Movement Screen (*FMS*) *Assessment Criteria and Classification*

Movement Task	Type of Movement Pattern Assessed	Scoring	Classification
FMS1 – Deep Squat	Hip, knee, ankle, and shoulder joint mobility	– 3 points – correct execution of the movement pattern; – 2 points – execution of the movement pattern with an element of compensation; – 1 point – unable to perform the movement pattern; – 0 points – pain during movement	– 18–21 points – correct movement patterns, the body moves properly, the risk of overload injury is minimal; – 14–18 points – movement patterns are disturbed, there are asymmetries and compensations – the risk of injury is estimated at 25–35%, – 14 points and fewer – the risk of injury is high, estimated at 50%
FMS2 – Hurdle Step	Lateral stability of the pelvis, trunk, and hips		
FMS3 – in-line lunge	Balance and stability of hip, knee and ankle joints		
FMS4 – shoulder mobility	Range of motion of the shoulder girdle		
FMS5 – active straight leg raise (ASLR)	Flexibility of the rear thigh muscles		
FMS6 – trunk stability push up	Stabilization of the torso during arm work and arm muscle strength		
FMS7 – rotational stability	Balance and rotational stabilization of the trunk		

Procedures

The research was conducted in April 2019 during mandatory physical education classes. During the classes, the students responded to surveys – Research Information and International Physical Activity Questionnaire (IPAQ) – its shortened, Polish version (Biernat et al., 2007). After completing the survey, the students were subjected to somatic measurements: body height using an anthropometre and body weight on the medical scales. Then they underwent functional assessment by means of the full FMS protocol, consisting of seven movement patterns, following the order described by the creators of the method: (1) “Deep squat”; (2) “Hurdle step”; (3) “In-line lunge”; (4) “Shoulder mobility”; (5) “Active straight-leg raise”; (6) “Trunk stability push-up”; and (7) “Rotary stability” (Cook et al., 2014a, 2014b). The assessments were conducted using the official FMS™ kit by a person certified and experienced to carry out assessments using this method. The assessor explained each movement pattern to the participants in a standard manner. The students made three attempts at each movement, and the best results were then selected for analysis. The ability to perform the movement pattern was assessed on a 4-point scale (0, 1, 2 or 3 points).The highest result from three attempts was recorded on a special sheet.

Statistical Analyses

The statistical analysis of the results was carried out using Statistica 13 software. The average level of physical activity expressed in MET-min/week units was presented along with the standard deviation (SD) and the range of variability (min-max) in individual categories of physical activity (PA) of the surveyed students, taking into account the division by gender. The numerical and percentage distribution of people in the respective categories of physical activity level (insufficient, sufficient, high) was also presented, considering gender divisions. The point results obtained as part of the FMS test (both in individual tests, as well as in terms of the overall result and results in individual categories of movement patterns) were presented using descriptive statistics (M, SD, min-max). The significance of statistical differences between the results of women and men was confirmed using the Mann-Whitney U test. A p value of less than 0.05 was considered to indicate statistical significance. Correlations between the types of physical activity (PA), level of physical activity (expressed as MET-min/week) and functional capacity (determined using the FMS test) were calculated using Spearman’s rank order correlation.

Results

Background Information and Demographics

The respondents were representatives of various fields of study and different living environments: large cities – 46.5%, small towns – 30.7% and villages – 22.8%. They declared to be in a good shape, as good health was reported by 99.1% of them, and only 8.1% mentioned suffering from chronic diseases, and 11.4% took medications regularly. Self-assessment of health was high. The health condition was assessed as very good by 34.3% of men and 36.4% of women, and as good by 54.3% of men and 34.1% of women. Self-assessment of physical fitness was also high: 28.6% of men rated their physical fitness as very good, 50% as good, and 15.7% as average. Among women, 25% declared very good, 34.1% good and 34.1% average physical fitness. Regular physical activity was mentioned by 45.5% of the women and 65.7% of the men, and periodic physical activity by 52.3% of the women and 34.3% of the men. The numerical characteristics of somatic features are presented in Table 2.

Table 2
Numerical characteristics of the height and weight of the examined students

Feature	Females (n = 44)				Males (n = 70)			
	M	SD	Min	Max	M	SD	Min	Max
Body mass [kg]	59.6	9.0	48	85	77.6	10.9	51	106
Body height [cm]	167.1	6.1	154	180	180.9	7.1	163	193

Level of physical activity of the surveyed male and female students

Compared to the female students, the male students revealed a generally higher overall level of physical activity (men – 5,210.8 MET; women – 3,422.7 MET). On average, higher rates of physical activity were achieved by the male students in all types of PA. The men and the women differed in terms of physical activity undertaken (Table 3). The female students were mainly active in the form of walking and intense exercise. The male students were more likely to engage in intense exercise rather than walking and doing moderate exercise.

Table 3
The level of physical activity expressed in MET-min/week units in individual categories of physical activity (PA) of the surveyed students

Feature	Females (n = 44)				Males (n = 70)			
	M	SD	Min	Max	M	SD	Min	Max
Walking	1553.6	1385.6	0	5940	1831.9	2396	0	11088
Moderate PA	694.5	761.3	0	3360	966.9	1085.8	0	5040
Intensive PA	1174.5	1262.6	0	4800	2412	2295.3	0	8640
Total PA	3422.7	2362.4	0	8865	5210.8	4050.8	0	23382

The surveyed male and female students were mainly characterized by a high level of physical activity, but their proportional share in the respective areas differed (Table 4). A high level of PA was observed in 88.6% of the male and 75% of the female students. A sufficient level of physical activity was achieved by 15.9% of the women and 4.3% of the men. 9.1% of the female students and 7.1% of the male students had an insufficient level of PA.

Table 4
The level of physical activity of the students by gender

Physical activity level	Females (n = 44)		Males (n = 70)	
	N	%	N	%
Insufficient	4	9.1	5	7.1
Sufficient	7	15.9	3	4.3
High	33	75	62	88.6
Total	44	100	70	100

The level of functional fitness of the surveyed male and female students

The surveyed male and female students show a similar average level of overall functional fitness (the men – 16.5 points, the women – 16.1 points). The results obtained by the respondents in individual attempts vary (Table 5). Only in two movement tasks was the average score the same: FMS4 (range of motion in the shoulder girdle) and FMS7 (balance and rotational stabilization of the trunk). The female students achieved statistically significantly higher results in two attempts: FMS3 (balance and stability of hip, knee and ankle joints) and FMS5 (flexibility of the rear thigh muscles). The male students performed better as far as the following three tests were concerned: FMS1 (mobility in the hip, knee, ankle and shoulder joints), FMS2 (level of lateral stability of the pelvis, trunk and hips) and FMS6 (trunk stability and arm muscle strength), with statistically significant differences only in the FMS6 sample. All respondents achieved the highest results in the FMS 4 and FMS5 tests.

Statistically significant differences also occurred for test samples classified as mobility (MP= FMS4 and FMS5) and stability (SP= FMS6 and FMS7) patterns. Compared to the male students, the female students achieved, on average, better results in test samples classified as mobility patterns (MP), the male students achieved better results in stability patterns (SP).

Table 5
Point values obtained by the subjects in the respective attempts of the FMS test and its general index and categories of movement patterns

Movement pattern	**Female (n = 44)**				**Male (n = 70)**				**U**	**Z**	***p***
	M	SD	min	max	M	SD	min	max			
FMS 1	1.9	0.8	0	3	2.1	0.7	0	3	1390	0.87	0.38
FMS 2	2.16	0.4	1	3	2.2	0.5	1	3	1413	0.74	0.46
FMS 3	2.8	0.4	2	3	2.3	0.5	1	3	924	−3.58	0.00
FMS 4	2.9	0.2	2	3	2.9	0.2	2	3	1514	0.15	0.88
FMS 5	2.9	0.3	2	3	2.6	0.6	1	3	1150	−2.27	0.02
FMS 6	1.5	0.7	1	3	2.3	0.7	1	3	690	4.95	0.00
FMS 7	2.1	0.4	1	3	2.1	0.3	1	3	1504	0.21	0.84
Total FMS	16.1	1.8	13	20	16.5	1.8	12	21	1368	1.00	0.32
GFA	2.07	0.5	1	3	2.2	0.5	1	3	1309	1.34	0.18
GP	6.80	1.2	4	9	6.6	1.2	4	9	1371	−0.98	0.33
MP	5.82	0.4	4	6	5.6	0.6	4	6	1173	−2.14	0.03
SP	3.50	0.8	2	5	4.3	0.8	3	6	750	4.60	0.00

GFA – general functional ability, GP – global patterns (FMS1 and FMS2 and FMS3), MP – mobility patterns (FMS 4 and FMS5), SP – stability patterns (FMS 6 and FMS7)

The level of functional fitness in most respondents (FMS test result in the range of 14–17 points) indicates the performance of movement patterns with compensation or asymmetry, which results in a 25-35% probability of injury. In this group, a higher percentage of women (70.5%) than men (67.1%) can be observed. Correct movement patterns (FMS test score above 18 points) are observed more often in the male students (28.6% of the respondents) than in the female ones (18.2% of the respondents). As for the level of functional fitness, indicating the lowest functional efficiency, the probability of injury increases to over 50% due to disturbed movement patterns (the score below 14 points in the FMS test) – 4.3% of the men and 11.4% of the women reported it.

Table 6
Assessment of the level of functional fitness of students by gender

Levels of functional ability	**Female (n = 44)**		**Male (n = 70)**	
	N	%	N	%
I – movement patterns disturbed, risk of injury 50%	5	11.4	3	4.3
II – movement patterns disturbed, risk of injury 25%-35%	31	70.5	47	67.1
III – correct movement patterns, minimal risk of injury	8	18.2	20	28.6

The relationship between physical activity and functional fitness in the surveyed students

There were statistically significant positive values of the correlation coefficient between the variable: V (intense PA) and FMS2 test trials ($r = 0.31$) and FMS 6 ($r = 0.28$), which indicates that with the increase in the duration of intense physical activity per week (e.g., fast running, fast cycling), the results of the attempt improve when it comes to lateral stability of the pelvis, trunk and hips and a trunk stability and arm muscle strength test (Table 7). Intense physical activity also shows a statistically significant positive correlation with stability patterns (SP = FMS6 + FMS7) ($r = 0.24$). Moreover, significantly positive correlations were noted between: total PA and FMS6 ($r = 0.23$) variable. It indicates that as the duration of total physical activity per week (total MET-min/week) of the surveyed students increases, the test result of trunk stability during symmetrical arm work and arm muscle strength improve. The coefficient values for the remaining pairs of variables do not show statistical significance.

Table 7
Spearman rank order correlations between types of physical activity (PA) and functional fitness as determined by the FMS test

Feature	W	M	V	Total PA
FMS1	0.06	0.06	0.07	0.06
FMS2	0.01	0.05	0.31*	0.17
FMS3	0.04	−0.03	−0.07	−0.09
FMS4	−0.09	0.01	−0.06	−0.13
FMS5	−0.05	−0.04	0.02	−0.08
FMS6	0.06	0.04	0.28*	0.23*
FMS7	−0.04	−0.06	−0.07	−0.12
Total FMS	0.02	−0.06	0.16	0.04
GFA	−0.06	0.03	0.12	−0.01
GP	0.05	0.03	0.12	0.05
MP	−0.07	−0.03	0.00	−0.10
SP	0.04	0.02	0.24*	0.18

W – walking, M – moderate PA, V – intense PA, GFA – general functional ability, GP – global patterns (FMS1 and FMS2 and FMS3), MP – mobility patterns (FMS 4 and FMS5), SP – stability patterns (FMS 6 and FMS7); * p<0.05, ** p<0.01

4. Discussion

Appropriate preparation of the body for physical activity constitutes the key element of training. Detecting abnormalities in functional efficiency can be helpful to minimize the risk of overload and injuries (Kochański et al., 2016). The FMS test is one of the tools that can be utilised to assess basic movement patterns. It can be used to assess people who engage in recreational or competitive activity.

Variations in FMS test scores have been observed in athletes in the context of the sport played and its proficiency level. For example, a study by Arslan et al. indicated that rowers had higher FMS test scores than soccer players (Arslan et al., 2021). In contrast, a study by Ridan et al. (2017) noted that soccer players had better FMS test scores than the control group. In weightlifting, for example, the average score was 18.08 points, with higher results for people with longer training experience (Adamczyk et al., 2012). Boxers scored an average of 14.84 points (Kochański et al., 2015), young female soccer players from China 16.2 points (Zhang et al., 2022), and NCAA Division 1 football students 14.3 ± 2.2 (Willigenburg & Hewett, 2017). A review analysis by Bonazza et al. (2017) demonstrates that athletes have limitations in movement patterns, which increases their risk of injury. As such, the Functional Movement Screen (FMS) test is gaining importance as a tool to identify asymmetries, weaknesses and movement limitations. Early detection of these problems leads to the implementation of targeted interventions and tailored training programs, which can reduce the likelihood of injury. The FMS test is also used to assess functional fitness in various professional groups. In soldiers, the average score was 14.8 points, with a greater risk of injuries observed with lower scores (Teyhen et al., 2012). Firefighters of the Volunteer Fire Department scored an average of 11.92 points, indicating a high risk of injuries (Kałużny et al., 2017). Physiotherapists scored an average of 13.51 points, with results ranging from 6 to 20 points (Kochański et al., 2016), which may suggest insufficient care for their own musculoskeletal system.

The results of our own research confirmed some of the tendencies described in the studies listed above. The functional efficiency of the surveyed students varies in general terms and in terms of basic movement patterns. The majority of the respondents obtained a result within the range of 14–17 points. This means that their movement patterns are disturbed, there are asymmetries and functional compensations, and the risk of overload injury is estimated at 25–35%. Correct movement patterns and minimal risk of injury, with a score of 18–21 points were more common among the men than the women. The score below 14 points, where the probability of sustaining an injury to the musculoskeletal system is estimated at 50%, was obtained by significantly more women than men.

The male and female students surveyed differed significantly in terms of movement patterns only in three tests: FMS3, FMS5 and FMS6. The men were, on average, better than the women in tests of trunk stability and rotational stability (SP), and the women performed better in active straight leg raises and arm mobility (MP) components, resembling the study by Schneiders et al. (2011). The women generally achieved better results in FMS3 and FMS4 tests, while the men achieved better results in FMS1, FMS2 and FMS6 tests. The highest number of points (2.9) was achieved by all subjects in FMS4 test (bilateral range of motion in the shoulder girdle) and by the women also in FMS5 test (flexibility of the rear thigh muscles). Most researchers agree that gender is not a factor differentiating the overall FMS test result within one research group. Schneiders et al. (2011), examining the functional efficiency of a population of active, healthy individuals, partially confirm the tendencies in gender differences in individual FMS test samples.

Some authors focus their research on analyzing gender variation in FMS test scores. Studies by Chimera et al. (2017) and Anderson et al. (2015) indicate that despite the lack of significant statistical differences in the total FMS test score between the sexes, significant differences are observed in the case of ratings of individual motor tasks of the FMS test. Also, Schneiders et al. (2011), studying the functional fitness of a population of active, healthy individuals, in part confirm the trend of gender differences in individual FMS test attempts. They showed that men performed better in a test requiring stability and strength (FMS3 – in-line lunge, FMS6 – trunk stability push up and FMS7 – rotational stability), while women scored higher in a mobility test (FMS4 – shoulder mobility, FMS5 – active straight leg raise). Gender differences in these tests were also confirmed by Miller and Susa's (2019) study of Division IA collegiate athletes. These studies coincide with the regularities of human biological development in the context of sexual dimorphism, especially with regard to the level of development of individual motor characteristics (Kaczmarek & Wolanski, 2018; Kibler et al., 1989).

The greatest area of scientific interest in the context of FMS concerns the relationship between the FMS test and the risk of injury. Research on the FMS test and its relationship to injury risk among athletes has yielded mixed results. Kolodziej and Jaitner (2018) conducted their research on a group of men – amateur soccer players. Their results indicate that soccer players who scored below 14.5 in the FMS test had twice the risk of injury compared to the rest of the study group. Moreover, the risk of injury was significantly higher among players who scored low on specific stability exercises. Another study, conducted by Landis et al. (2018) on a group of 187 women practising various sports at the university level, showed significant differences in the FMS test results between athletes with and without injuries. FMS scores were lower among women with injuries, suggesting that the test may be used to identify female athletes at a higher risk of injury. Kiesel et al. (2007) found in their study that athletes with an FMS score of 14 or less had as much as 11 times the risk of in-season injury compared to those who had a score of 15 or more. These results demonstrate the potential merit of the FMS test as a tool for predicting injury risk. In contrast, other authors suggest that the FMS test can be a useful tool to identify athletes with an increased risk of injury, but that a low FMS test score has no direct correlation to injury occurrence. Dorrel et al., 2015 indicate that the diagnostic accuracy of FMS for predicting injury is low. A study by De la Motte et al. (2019) found little predictive value and limited clinical utility of the FMS test. Maltownik et al. (2017) also found no clear relationship between FMS scores and injury risk among handball players.

Other research points to the link between muscle flexibility and the risk of injury. De la Motte et al. (2019) and Witvrouw et al. (2004) noticed that athletes with less muscle flexibility were more susceptible to injuries. Bradley and Portas (2007) confirmed these results, indicating that greater muscle flexibility may provide athletes with a safeguard against injuries.

The quality of movement patterns and the level of physical fitness influence the risk of injury, which raises further questions as to their relationship (Koźlenia & Domaradzki, 2021; Lisman et al., 2013). In literature, attempts have been made to establish relationships between functional and physical fitness, but certain differences in observations do not allow for definite conclusions on this issue to be reached. In the research by Koźlenia and Domaracki (2021), in young, healthy women, the abdominal muscle flexibility and strength are significantly associated with the quality of movement patterns, expressed as the overall FMS score and FMS asymmetries. Moreover, flexibility is the component of physical fitness that exerts the most substantial impact on the quality of movement patterns in the overall FMS score and the number of asymmetries, while abdominal muscle strength only affects asymmetries in FMS. These results indicate the importance of abdominal muscle flexibility and strength for the quality of movement patterns among young women. The appropriate range of motion in the joints with the strength of the abdominal muscles that provides trunk stability helps avoid movement compensation. This potentially suggests that FMS outcomes may be shaped during the development of abdominal muscle flexibility and strength (Koźlenia & Domaradzki 2021).

The research by Lloyd et al. (2015), on the other hand, revealed that among young soccer players (aged 11-16), a deep overhead squat, in-line lunge, active straight leg raise and rotational stability test were significantly correlated with all physical fitness tests performed. This study showed that variation in the physical fitness of young soccer players could account for the performance of the functional test.

There are questions among researchers as to the relationship between the level of physical activity and the level of functional fitness assessed by the FMS test. In our own research, the men were more physically active (5210.8 MET-min/week) than the women (3422.7 MET-min/week). The male students more often performed intensive exercise (PA = 2412 MET-min/week), while the female students preferred walking activity (PA = 1553.6 MET-min/week). Moderate activity undertaken by the male and female students is clearly lower (F = 694.5 and M = 966.9 MET-min/week). No significant relationship between moderate physical activity and walking with FMS test results was found. Only the results of test 6 (stabilization of the torso during arm work and arm muscle strength) significantly correlated with the total and intense physical activity of the respondents. FMS2 – assessing the functional stabilization of the pelvis, trunk, and hips was only associated with intense physical activity. Moreover, intense physical activity also shows a statistically significant positive correlation with stability patterns (SP = FMS6 + FMS7).

Other studies also confirm that low total physical activity (expressed in MET-min/week) has no significant relationship with FMS test results among students (Liu et al., 2023). In the same study, regression analysis was used to show the relationship between individual variables, including the level of physical activity, BMI, FMS test result, and sports injuries. It was shown that the composite FMS score and the level of physical activity, expressed in MET-min/week, are a more significant predictor of sports injuries than gender, BMI and age. The study demonstrated that the FMS composite score is an acceptable predictor of injury in a sample of college students with low to moderate levels of physical activity. It indicates that the FMS result can correctly identify people at risk of sports injury who belong the group of low and moderate levels of physical activity.

The cited studies can be accounted for by the fact that people with low and moderate physical activity often exhibit impaired movement patterns, resulting in greater susceptibility to injury. In contrast, in people with high physical activity, the risk of injury, despite good motor preparation, is associated with many other factors, especially in a dynamic and unpredictable sports environment, hence the predicting and preventing acute emergency injuries is extremely difficult.

5. Conclusions

1. The surveyed male and female students are characterized by a high level of physical activity. The men are more active and engage in intense activity, while the women engage in more frequent walking.
2. In most subjects, movement patterns are disturbed due to asymmetries and functional compensations that require preventive measures and compensatory exercises. The risk of injury estimated based on the FMS assessment is 25 – 35%.
3. The probability of sustaining an injury to the musculoskeletal system is estimated at 50% and it occurs more often in the women. Participating in special exercise programs improving weak links in the kinematic chain is recommended.
4. Compared to the male students, the female students achieved, on average, better results in test samples classified as mobility patterns (MP), the male students achieved better results in stability patterns (SP).
5. Significant relationships are observed between intense physical activity of the surveyed students and lateral stabilization patterns of the pelvis, trunk and hips (FMS 2), trunk stabilization (FMS6) and stability patterns (SP = FM6 + FMS7). Total physical activity shows a significant positive correlation only with the test assessing trunk stabilization (trunk stability push up).

Statement of Ethics

This study was conducted in accordance with the World Medical Association Declaration of Helsinki. The study protocol was reviewed and approved by the Bioethics Committee of the Regional Medical Council in Zielona Góra (No. 07/118/2019, Zielona Góra, Poland). All participants provided written informed consent to participate in this study.

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