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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Reliability and objectivity of the susceptibility test of the body injuries during a fall of physiotherapy students

Jarosław Klimczak[1ABCD], Michał Oleksy[2ABCD], Bartłomiej Gąsienica-Walczak[3ABCDE]

[1]*Department of Tourism and Recreation, University of Warmia and Mazury in Olsztyn, Poland*
[2]*Sports Club Judo Kraków, Poland*
[3]*Health Institute, Podhale State College of Applied Sciences in Nowy Targ, Poland*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim Falling is an increasingly frequent problem. Assessment of the ability to control the body parts that are most susceptible to injury during a fall is the primary goal of prevention of fall-related injuries. The susceptibility test of the body injuries during a fall (STBIDF) is of note. To date, investigations of the STBIDF have been limited to validity assessment. Aim. Verify the reliability and objectivity of the STBIDF test.

Material and Methods Thirty-five female physiotherapy students participated in this study voluntarily. The sample was selected from 45 males and females undertaking their first-degree studies during the fifth semester of 2017–2018 at Podhale State College of Applied Sciences (PSCAS) in Nowy Targ, Poland. The STBIDF questionnaire was applied. Each student was recorded during STBIDF test performance. The STBIDF reliability assessment was performed using the test-retest method. The STBIDF objectivity assessment was performed using the Delphi method, with a panel consisting of three experts.

Results A significant correlation ($r_s = 0.865$, $p < 0.001$) between the $Index_{SBIDF}$ scores for the test and retest was observed. The Wilcoxon signed-rank test result did not reveal any significant differences between the test and retest.

Conclusions The STBDIF is characterized by reliability and objectivity; therefore, it is a good tool for analysis of the susceptibility to injury of the body parts most exposed during falls in people from different risk groups. This non-apparatus test is a reliable and easy to use tool, available for experts dealing with falls and their consequences, and preventive approaches. It can also be used in medical, pedagogical, and athletic environments.

Keywords: safe fall, concordance of assessments, motoric simulations, different risk groups

Introduction

Falls are a growing social [1-3] and economic [4, 5] issue. According to the World Health Organization (WHO), every year 646, 000 people die due to falls and 37.3 million require medical care [6]. The global rankings of injuries from 2017, that compares causes of death, years lived with disability (YLDs), and disability-adjusted life years (DALYs), classifies falls as the first to third most frequent cause of these incidence [7]. Dobosz et al. [8] identified that the surface on which people fall determines the consequences of falling. According to this ranking [7], Central and Eastern Europe are the leaders, with the rate of falls lowest in sub-Saharan Africa.

The Fall Prevention Model developed by the WHO is composed of three pillars. The first pillar involves building awareness of fall prevention. The second pillar involves improvement of recognition and assessment of risk factors for falls. The third pillar involves the development and implementation of realistic and successful interventions [9]. The second pillar is based on the paradigm that it is possible to eliminate falls from one's life or maximally limit their incidence, and this criterion is dominant in preventive programs. In our opinion, combining the programs aimed at fall limitation with the programs aimed at teaching safe fall techniques is the most optimal solution [10].

Jaskólski and Nowacki [11] have developed the theory of "soft falling". Thanks to their well-justified premises, they combine the sense of body injury prevention in cases of balance loss, falls and contact with the surface, with the ability to lose energy during falls. Mroczkowski [12] has extended this theory by analyzing human body deformation energy during rotational movement performance on the surface. Empirical studies [8, 13] provide evidence for the effectiveness of the so-called Kalina's methods. These methods, verified many times, are based on teaching how to overcome the consequences of balance loss and contact with the surface. An optimal level of muscle strength, flexibility and balance (developed for the circumstances and motor activities to ensure protection of distal body parts and the entire organism, or to minimize the destructive consequences of falls and body contact with the surface) is fundamental [10].

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Effective prophylaxis of fall-related body injuries for individuals begins with an accurate assessment of the quality of control over the body parts that are most exposed to injury. Granhed et al. [14] reviewed the papers on fall-related body injuries. The most exposed body parts included: hips and the upper limbs in people who fell at the same level; lower limbs in persons who fell from heights; the spine and the head; the chest (especially in people who fell from height); and the abdominal cavity (in falls from extreme heights).

The reference sources recommend different approaches to fall risk assessment. These include the Berg Balance Scale [15]; the Falls Efficacy Scale [16]; the Aachen Falls Prevention Scale [17]; and the Short Falls Efficacy Scale International [18]. The motoric tests include the Timed "Up & Go" Test [19] and the Functional Reach Test [20], as well as tests using biomechanical devices [21, 22]. Other good examples of the limited usefulness of these sorts of tools in the prognosis of falls in older people, especially the consequences of such incidents, are the conclusions pertaining to the externally validated accuracy of Fall Risk for Older People in the Community (FROP-Com) [23].

Therefore, the susceptibility test of the body injuries during a fall (STBIDF) is of note [24, 25]. It belongs to the non-apparatus test category, and is safe and easy to apply in clinical and population screening studies. A simple motor simulation of a backward fall on a soft surface enables observation of the body parts that are most exposed to injuries after contact of the body with the surface. The quantified results of this observation (scores) are a simple measure of injury risk for single or multiple body parts in cases of falls during everyday physical activities. The Information Scale on Safe Ways of Falling (INFOSECA) developed by Toronjo-Hornillo et al. [26] assesses motor activities in people during backward falls. Although the approach to identification of the body parts that are most exposed to fall-related injuries is very similar to the STBIDF, the authors of the above mentioned scale cite the review paper presenting test results [27] without mentioning the reference sources [24, 25].

To date, the STBIDF validation procedure has been limited to validity assessment [25]. According to the highest standards of research methodology, the author of a motoric test should not verify its reliability personally. This condition is fulfilled by the results obtained in our study. Among the approaches to reliability assessment, the test-retest approach is most often applied [28-30]. Moreover, the rule is "a trial is objective when it is performed by (at least) two experts using the same human material and its results are identical or very similar" [31]. Therefore, the aim of the present study was to verify the reliability and objectivity of the STBIDF.

Material and methods

Participants

The sample included 35 female physiotherapy students (21.3 ± 0.8 years of age). The sample was selected from 45 males and females undertaking their first-degree studies during the fifth semester of 2017–2018 at Podhale State College of Applied Sciences (PSCAS) in Nowy Targ, Poland. The following inclusion criteria were applied: an adequate health state, voluntary participation, and gender (female). The exclusion criteria were: a lack of consent for participation in the study, pregnancy, and dysfunctions making it impossible to undergo the test. All participants were informed in detail about the aim of the study prior to participation. The study was accepted by the Bioethics Committee at the Regional Medical Chamber in Gdansk, Poland, Resolution KB – 17/17.

Procedures

Assessment of the susceptibility to body injuries during a fall

The STBIDF was applied [24, 25]. Each student was recorded during test performance in such a way that the camcorder was recording the required motor activities in the sagittal plane. The participants waiting for the test were in another room, and they could not contact those who had already performed the test.

The structure of the STBIDF included three motoric tasks performed on tatami (martial arts) mats. The manner of protecting body parts that were most exposed to injuries during a fall (head, hands, hips, legs) was assessed. Any incorrect collision, as indicated by the fastest possible change of posture from vertical (standing) to horizontal (lying on the back), was recorded as a first ("1") or second grade ("2") error, with no errors recorded as "0". The total score is used as general indicator of the susceptibility to body injuries during a fall (i.e., the $Index_{SBIDF}$), with scores classified as low (0), average (1–3), high (4–8), and very high (9–14). The scores obtained for individual body parts were classified as low (0), average (1), and high (2–6) [24, 25].

Assessment of the reliability of the STBIDF using a test-retest approach

The test was recorded twice. The second measurement (i.e., retest) was taken seven days after the first test (i.e., test). Each participant performed the test and retest on their own. The test and retest were performed at the same time of the day, in the same room, and using identical procedures.

Assessment of the objectivity of the STBIDF using the Delphi method (expert panel)

The method of direct secondary observation with the possibility of multiple replays was applied. The assessment procedure involved observation of video recordings of the two stages of the study (i.e., test and retest) by three experts experienced in using the STBIDF. First, the experts independently assessed the recordings and did not share their views. In the case of discrepancies between the scoring, the experts assessed the recordings together (multiple times if required), and verbalized their opinions before reaching a consensus on the final result.

$Index_{RC}$ is the number (expressed in %) of consensus ratings made by experts (independently) in a test and retest.

Statistical analysis

Normality was assessed using the Shapiro-Wilk test. The obtained scores were not normally distributed; therefore, further analyses were conducted using nonparametric methods. Differences between test and retest scores were analyzed using the Wilcoxon signed-rank test, with the alpha level set at < 0.05. Spearman's rank correlation coefficient was used to analyze associations between variables (for example test $Index_{SBIDF}$ and retest $Index_{SBIDF}$). Arithmetic means ($\bar{X}$), standard deviations (SD), minimal (min) and maximal (max) scores (i.e., range), and skew (g1) and kurtosis (g2) were calculated.

Results

The difference between the $Index_{SBIDF}$ scores obtained in the test and those obtained in the retest was 0.2 points according to expert A, and 0.14 points according to expert B, with no difference observed by expert C (Table 1). The biggest difference 0.26 points (calculated on the basis of the data in Table 2) in the mean STBIDF scores was found between expert B's and expert C's assessments for the test.

The experts' mean scores for the test $Index_{SBIDF}$ and retest $Index_{SBIDF}$ were similar for their analyses carried out together at the same time (in the case of discrepancies between the scoring, the experts assessed the recordings together). The differences obtained for the first, second, and third tasks were 0.03 points, 0.08 points, and 0.08 points respectively, and the difference for the $Index_{SBIDF}$ was 0.02 points. A significant correlation between the $Index_{SBIDF}$ test and retest scores was observed ($r_s = 0.865$, $p < 0.001$). The Wilcoxon signed-rank test did not reveal any

Table 1. Mean scores obtained for STBIDF (test-retest) assessment by three independent experts (A, B, C).

Expert statistics		STBIDF test result (score) 1		2		3		$Index_{SBIDF}$ (score)	
		test	retest	test	retest	test	retest	test	retest
A	$\bar{X}$	2.69	2.63	2.54	2.57	3.66	3.49	8.89	8.69
	SD	1.02	0.88	0.92	0.7	1.08	1.01	2.56	1.98
	min	1	0	1	1	2	1	4	4
	max	4	4	4	4	6	6	14	12
B	$\bar{X}$	2.74	2.66	2.57	2.63	3.66	3.54	8.97	8.83
	SD	1.01	0.91	0.81	0.69	1	0.95	2.33	2.01
	min	1	0	1	1	2	2	4	4
	max	4	4	4	4	6	6	14	14
C	$\bar{X}$	2.63	2.6	2.49	2.6	3.6	3.51	8.71	8.71
	SD	0.84	0.91	0.82	0.77	0.85	1.09	1.84	2.27
	min	1	0	0	1	2	1	5	3
	max	4	4	4	4	5	6	13	14

Table 2. Differences in mean $Index_{SBIDF}$ scores and rating compatibility index $Index_{RC}$ (%).

Stages and expert assessments		Test		
		$\bar{X}$ $Index_{SBIDF}$	$\bar{X}$ $Index_{SBIDF}$	$\bar{X}$ $Index_{SBIDF}$
		$Index_{RC}$	$Index_{RC}$	$Index_{RC}$
	Expert	A	B	C
Retest	A		0	0.06
			77.14	74.29
	B	0.05		0.06
		94.29		80
	C	0.02	0.03	
		88.57	82.86	

significant differences between the test $Index_{SBIDF}$ and retest $Index_{SBIDF}$ scores (Table 3).

The concordance of assessments between expert A and expert B for the retest was 94.29 % (Table 2), and no significant differences between the results were observed.

All correlations between test and retest scores as determined by the experts together were significant ($p < 0.001$). The highest correlation coefficient was observed for $Index_{SBIDF}$ scores, while the lowest correlation coefficient was observed between the scores obtained from the third task (Table 3). However, the lack of significant differences in the results of individual body part assessment by each expert is the most convincing empirical evidence, indicating that the evaluation criteria are precise and that they did not change during the period between the test and retest (Table 4).

High correlation coefficients between the test and retest $Index_{SBIDF}$ scores and between-expert $Index_{SBIDF}$ scores were observed. For the test, differences were found between the experts' scores: between experts A and B and experts A and C = 0.942 ($p < 0.001$); and between experts B and C = 0.937 ($p < 0.001$). Differences between the experts were also observed for the retest: between experts A and B = 0.992 ($p < 0.001$); between experts A and C = 0.963 ($p<0.001$); and between experts B and C = 0.945 ($p < 0.001$).

Discussion

The STBIDF improves identification and assessment of the risk factors highlighted by the WHO in the second pillar recommendations [9]. The STBIDF can be used by anyone who has read the description and adheres to the methodological recommendations [24]. However, only experienced

Table 3. Mean scores of STBIDF (test-retest) after all experts' corrections.

Statistic Indicator	Scores obtained from STBIDF (points) 1		2		3		$Index_{SBIDF}$ (score)	
	test	retest	test	retest	Test	retest	test	retest
$\bar{X}$	2.66	2.63	2.49	2.57	3.57	3.49	**8.71**	**8.69**
SD	1.03	0.88	0.85	0.7	1.01	1.01	**2.38**	**1.98**
min	1	0	1	1	2	1	**4**	**4**
max	4	4	4	4	6	6	**14**	12
g1	−0.6	−1.39	−0.05	−0.27	0.07	−0.05	**−0.17**	**−0.5**
g2	−0.44	1.69	0.49	0.04	−0.25	0.58	**−0.13**	**0.26**
Spearman rank correlation	0.816***		0.772***		0.572***		**0.865*** **	
Wilcoxon test p value (exact)	0.82		0.46		0.49		**0.87**	

***$p < 0.001$

Table 4. Mean score and standard deviation corresponding to susceptibility of the predetermined parts of the body to injuries in physiotherapy students (n = 35).

Stages	Body parts in STBIDF tasks (score) 1			2			3			
	hips	arms	head	hips	arms	head	legs	hips	arms	Head
Expert A										
Test	0.23±0.43	1.51±0.82	0.94±0.24	0.2±0.41	1.57±0.56	0.77±0.43	0.94±0.84	0.2±0.41	1.63±0.49	0.89±0.32
Retest	0.14±0.36	1.60±0.77	0.89±0.32	0.11±0.32	1.6±0.5	0.86±0.36	0.74±0.7	0.2±0.41	1.63±0.55	0.91±0.28
Difference	0.09	0.09	0.05	0.09	0.03	0.09	0.2	0	0	0.02
Expert B										
Test	0.29±0.46	1.51±0.82	0.94±0.24	0.17±0.38	1.6±0.5	0.8±0.41	0.83±0.82	0.31±0.47	1.63±0.49	0.89±0.32
Retest	0.17±0.38	1.6±0.77	0.89±0.32	0.14±0.36	1.6±0.5	0.89±0.32	0.8±0.72	0.2±0.41	1.63±0.55	0.91±0.28
Difference	0.12	0.09	0.05	0.03	0	0.09	0.03	0.11	0	0.02
Expert C										
Test	0.17±0.38	1.51±0.82	0.94±0.24	0.2±0.41	1.6±0.6	0.69±0.47	0.8±0.83	0.26±0.44	1.63±0.49	0.91±0.28
Retest	0.11±0.32	1.6±0.77	0.89±0.32	0.17±0.38	1.6±0.5	0.83±0.38	0.74±0.7	0.23±0.43	1.63±0.55	0.91±0.28
Difference	0.06	0.09	0.05	0.03	0	0.14	0.06	0.03	0	0

experts have numerous opportunities to track individuals' behavior and activities to find out whether these (namely conscious behavior during different formal exercises, motoric simulations, and some forms of play fighting [32]) lead to errors or optimal actions. The STBIDF has been frequently applied [27] in samples of athletes (e.g., judoka or karateka) [33], individuals who do not train [34], individuals with disabilities [35, 36] and visual impairments [37, 38], and limb amputees [39].

Kalina et al. [25] first applied the STBIDF in 2010 for the assessment of female physiotherapy students who completed motoric simulations of falling by blind people and limb amputees. The obtained scores were used in the validation procedure (test validity assessment) for the STBIDF. The STBIDF was observed to be a very sensitive tool, able to verify changes in body susceptibility to fall-related injuries in physiotherapy students, patients with visual impairment, and footballers after limb amputation or with malformed limbs (AMP football players) [40]. There was only one case of a patient with morbid obesity [41]. An extended analysis of the STBIDF results revealed opportunities for simple brain plasticity assessment [38]. This conclusion is in agreement with the opinions presented by, amongst others, Bennett et al. [42].

Due to the multiple motoric elements repeated at potentially high speeds (the requirement of fall dynamics simulation), three experts highly experienced in athlete observation during training and competition (especially combat sports and games) assessed the recordings. This approach is very effective. The recording can be replayed several times, and in case of any doubt's playback can be slowed or stopped when necessary. On completion of the tests, the experts recommended recording task performance from both sides of the participant. It was noted that assessment of head-to-surface contact can be problematic if a participant has a hair bun (as in the case of one participant in our study), and that assessment of hip control may be biased if a participant wears oversized clothing that prevents observation of the moment of contact with the surface. In our opinion, the observer's perception is also an important factor. During observer training it is important to note how many times a candidate has to replay a recording to see the details required for the final assessment.

This study has shown a high concordance of assessment. The mean level of the difference obtained from $Index_{SBIDF}$ scores was lower for the first-grade error. According to the quote that states "the trial is objective when it is performed (at least) by two different persons with the same human sample and its results are identical or very similar"[31], the STBIDF should be regarded as objective, whilst high and significant correlation coefficients obtained using the test-retest approach indicate its reliability. This conclusion is further supported by the lack of significant differences between test-retest scores.

Assessment of a fall under laboratory conditions is often performed using state-of-the-art programs based on biomechanics and computer systems that enable multiplane analyses. Unfortunately, this instrumentation is expensive [21, 22] and the scale of fall consequence phenomenon [6] requires the use of simple approaches to observation that are quick and, most importantly, cheap. A special application for smartphones that facilitates documentation of observations and assessment of results would be beneficial. Our study results confirm the finding that the STBIDF, as a simple tool of participant observation during simulated falls, provides empirical data that enables valid, reliable and objective analysis of susceptibility to injuries that may be sustained by older people who fall whilst undertaking everyday physical activities in their apartments, gardens, and houses [43].

Conclusions

The STBDIF is characterized by reliability and objectivity; therefore, it is a good tool for analysis of the susceptibility to injury of the body parts most exposed during falls in people from different risk groups.

This non-apparatus test is a reliable and easy to use tool, available for experts dealing with falls and their consequences, and preventive approaches. It can also be used in medical, pedagogical, and athletic environments.

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Conflicts of interest

The authors declare no conflicts of interest.

References

1. Chaudhary S, Figueroa J, Shaikh S, Mays EW, Bayakly R, Javed M, et al. Pediatric falls ages 0–4: understanding demographics, mechanisms, and injury severities. *Inj Epidemiol*, 2018;5 (Suppl 1):7. https://doi.org/10.1186/s40621-018-0147-x
2. Schick S, Heinrich D, Graw M, Aranda R, Ferrari U, Peldschus S. Fatal falls in the elderly and the presence of proximal femur fractures. *Int J Legal Med*, 2018;132:1699–712. https://doi.org/10.1007/s00414-018-1876-7
3. Wu H, Lu N, Wang C, Tu X. Causal effects of informal care and health on falls and other accidents among the elderly population in China. *Qual Life Res*, 2018;27:693–705. https://doi.org/10.1007/s11136-017-1665-7
4. Heinrich S, Rapp K, Rissmann U, Becker C, König H-H. Cost of falls in old age: a systematic review. *Osteoporos Int*, 2010;21:891–902. https://doi.org/10.1007/s00198-009-1100-1
5. Florence CS, Bergen G, Atherly A, Burns E, Stevens J, Drake C. Medical Costs of Fatal and Nonfatal Falls in Older Adults: Medical Costs of Falls. *J Am Geriatr Soc*, 2018;66:693–8. https://doi.org/10.1111/jgs.15304
6. *World Health Organization. Falls* [Internet]. 2020 [updated 2020 Jun 15; cited 2020 Sep 04]. Available from: https://www.who.int/news-room/fact-sheets/detail/falls
7. *Institute for Health Metrics and Evaluation. Global Burden of Diesease (GBD)* [Internet]. 2020 [updated 2020 Jun 15; cited 2020 Sep 04]. Available from: https://vizhub.healthdata.org/gbd-compare/
8. Dobosz D, Barczyński BJ, Kalina A, Kalina RM. The most effective and economic method of reducing death and disability associated with falls. *Arch Budo,* 2018;14:239–246.
9. Yoshida – Intern S. *A Global Report on Falls Prevention. Epidemiology of Falls*. Ageing and Life Course. Family and Community Health. World Health Organization; 2007.
10. Kalina RM, Barczyński BJ, Jagiełło W, Przeździecki B, Kruszewski A, Harasymowicz J, et al. Teaching of safe falling as most effective element of personal injury prevention in people regardless of gender, age and type of body build – the use of advanced information technologies to monitor the effects of education, *Arch Budo,* 2008;4(4): 82–90.
11. Jaskólski E, Nowacki Z. *Theory, methodology and systematics of soft falls. Part I. The theory of safe falls.* Wrocław: WSWF; 1972. P. 83–88. (In Polish).
12. Mroczkowski A. Motor safety of a man during a fall. *Arch Budo,* 2015;11:293–303.
13. Gąsienica Walczak B. Acceptance of the sense of implementing safe fall programs for people with visual impairments or after amputation of limbs – the perspective of modern adapted physical activity. *Physical Education of Students,* 2019;23(6):288–96. https://doi.org/10.15561/20755279.2019.0603
14. Granhed H, Altgarde E, Akyurek LM, David P. Injuries Sustained by Falls – A Review. *Trauma Acute Care*, 2017;2:38.
15. Berg KO, Wood-Dauphinee SL, Williams JI, Gayton D. Measuring balance in the elderly: preliminary development of an instrument. *Physiother Can*, 1989;41:304–311. https://doi.org/10.3138/ptc.41.6.304
16. Tinetti ME, Richman D, Powell L. Falls efficacy as a measure of fear of falling. *J Gerontol*, 1990;45:239–243. https://doi.org/10.1093/geronj/45.6.P239
17. Pape H-C, Schemmann U, Foerster J, Knobe M. The 'Aachen Falls Prevention Scale' - development of a tool for self-assessment of elderly patients at risk for ground level falls. *Patient Saf Surg*, 2015;9:7. https://doi.org/10.1186/s13037-014-0055-0
18. Kamide N, Shiba Y, Sakamoto M, Sato H. Reliability and validity of the Short Falls Efficacy Scale-International for Japanese older people. *Aging Clin Exp Res*, 2018;30:1371–7. https://doi.org/10.1007/s40520-018-0940-y
19. Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc*, 1991;39:142–148. https://doi.org/10.1111/j.1532-5415.1991.tb01616.x
20. Duncan PW, Studenski S, Chandler J, Prescott B. Functional Reach: predictive validity in a sample of elderly veterans. *J Gerontology*, 1992;47:93–98. https://doi.org/10.1093/geronj/47.3.M93
21. Vallabh P, Malekian R. Fall detection monitoring systems: a comprehensive review. *J Ambient Intell Human Comput*, 2018;9:1809–1833. https://doi.org/10.1007/s12652-017-0592-3
22. Ribeiro NF, André J, Costa L, Santos CP. Development of a Strategy to Predict and Detect Falls Using Wearable Sensors. *J Med Syst*, 2019;43:134. https://doi.org/10.1007/s10916-019-1252-2
23. Mascarenhas M, Hill KD, Barker A, Burton E. Validity of the Falls Risk for Older People in the Community (FROP-Com) tool to predict falls and fall injuries for older people presenting to the emergency department after falling. *Eur J Ageing*, 2019;16:377–86. https://doi.org/10.1007/s10433-018-0496-x
24. Kalina RM. Soft landing. *Medical Tribune*, 2009;7(13):28-29. (In Polish).
25. Kalina RM, Barczyńsk BJ, Klukowski K, Langfort J, Gasienica-Walczak B. The method to evaluate the susceptibility to injuries during the fall – validation procedure of the specific motor test. *Archives of Budo,* 2011;7(4):203–216.
26. Toronjo-Hornillo L, DelCastillo-Andrés Ó, Campos-Mesa M, Díaz Bernier V, Zagalaz Sánchez M. Effect of the Safe Fall Programme on Children's Health and Safety: Dealing Proactively with Backward Falls in Physical Education Classes. *Sustainability*, 2018;10:1168. https://doi.org/10.3390/su10041168
27. Kalina RM, Mosler D. Risk of Injuries Caused by Fall of People Differing in Age, Sex, Health and Motor Experience. In: Ahram T, editor. *Advances in Human Factors in Sports, Injury Prevention and Outdoor Recreation*, vol. 603, Cham: Springer International Publishing; 2018. P. 84–8. https://doi.org/10.1007/978-3-319-60822-8_8

28. Guttman L. A basis for analyzing test-retest reliability. *Psychometrika*, 1945;10:255–82. https://doi.org/10.1007/BF02288892
29. Donskoy D, Zaciorski W. *Biomechanics*. Moscow; 1979. (In Russian).
30. Heyward VH. *Advanced fitness assessment and exercise prescription*. 5th ed. Champaign: Human Kinetic; 2006.
31. Raczek J, Mynarski W, Ljach W. *Shaping and diagnosing coordination motor skills*. Katowice: APE; 2002. (In Polish).
32. Jagiełło W, Kalina RM, Klimczak J, Ananczenko KV, Ashkinazi S, Kalina A. Fun forms of martial arts in positive enhancement of all dimensions of health and survival abilities. In: Kalina RM (ed.) *Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach*, HMA 2015, 17–19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015. P. 32–39.
33. Adamczyk JG, Antoniak B, Boguszewski D, Siewierski M. The physical fitness and the safety falling skills of karatekas. *J. Combat Sport Martial Arts*, 2012;3:53–58.
34. Boguszewski D, Kerbaum K. Judo training as a means of reducing susceptibility to injury during a falls. *Polish J. Sport. Med*, 2011; 27(3):205– 212. https://doi.org/10.5604/1232406X.971228
35. Mosler D, Kmiecik-Małecka E, Kalina RM. Changes in susceptibility to injury during the fall of patients with mental disorders covered by a special six-month cognitive-behavioral therapy. *International Scientific Conference Physiotherapy and Health Activity*. Academy of Physical Education, Katowice, Poland, 2014. P.100-110. (In Polish).
36. Mosler D. Changes of susceptibility of body injuries during a fall of patients with mental impairment participating for several months in special cognitive-behavioural therapy. In: Kalina RM (ed.) *Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach*, HMA 2015, 17–19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015. P. 196–198.
37. Boguszewski D, Zabłocka M, Adamczyk J. Susceptibility to injury during a fall among blind children. *Adv. Rehabil*, 2012; 26: 5–12. https://doi.org/10.2478/rehab-2013-0039
38. Gąsienica Walczak B, Barczyński BJ, Kalina RM. Evidence-based monitoring of the stimuli and effects of prophylaxis and kinesiotherapy based on the exercises of safe falling and avoiding collisions as a condition for optimising the prevention of body injuries in a universal sense – people with eye diseases as an example of an increased risk group. *Arch Budo*, 2018;13:79–95.
39. Gąsienica Walczak B, Kalina A. Susceptibility of body injuries during a fall of people after amputation or with abnormalities of lower limb. In: Kalina RM (ed.) *Proceedings of the 1st World Congress on Health and Martial Arts in Interdisciplinary Approach*, HMA 2015, 17–19 September 2015, Czestochowa, Poland. Warsaw: Archives of Budo; 2015. P. 193–195.
40. Gąsienica-Walczak B. *Motor, methodical and mental qualifications of physiotherapy students in the field of safe falling - the perspective of preventing falls in people with visual impairments, an immobilized or amputated limb.* [PhD Thesis]. Rzeszow: University of Rzeszów, Faculty of Medicine; 2017. (In Polish).
41. Gąsienica Walczak B, Barczyński B, Kalina RM. Fall as an extreme situation for obese people. *SMAES*, 2019;15.
42. Chemical and anatomical plasticity of brain. 1964 [classical article]. *Neuropsychiatry Clin Neurosci*, 1996;8:459–70. https://doi.org/10.1176/jnp.8.4.459
43. Mulley G. Book of the Month Falls in Older People. *J R Soc Med*, 2001;94:202–202. https://doi.org/10.1177/014107680109400417

Information about the authors:

Jarosław Klimczak; https://orcid.org/0000-0003-2465-0799; klimczakwmrot@op.pl; Department of Tourism and Recreation, University of Warmia and Mazury in Olsztyn; Olsztyn, Poland.

Michał Oleksy; Student; https://orcid.org/0000-0003-1475-8691; michal_oleksy@o2.pl; Sports Club Judo Kraków; Kraków, Poland.

Bartłomiej Gąsienica-Walczak; (Corresponding author); PhD; https://orcid.org/0000-0001-7818-6333; bartlomiej.gasienica@ppuz.edu.pl; Health Institute, Podhale State College of Applied Sciences in Nowy Targ; Nowy Targ, Poland.

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ORIGINAL ARTICLE

Investigation of the effect of acute badminton training on selected biomotoric parameters

Nurkan Yılmaz[ABCDE]

Department of Physical Education and Sports Teaching, Faculty of Sport Sciences, Inonu University, Turkey

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim	One of the fastest racquet sports in the world, badminton is defined as a versatile, explosive sprint sport that requires players to perform intense rhythmic movements with its highly competitive and dynamic feature. The aim of this study is to investigate the effectiveness of 4-week badminton training on some selected biomotoric features in young individuals engaged in recreational sports.
Material and Methods	Twenty seven students of sports sciences voluntarily participated in the study (age = 18.85 ± 0.98 years). A total of 4 weeks of training was given for 2 hours a day specific to badminton sport. We examined the effects of pre-post training development of biomotoric properties, flexibility, reaction, vertical jump, balance and agility parameters on performance. Statistical analyzes of the data obtained as a result of the research were obtained using the IBM SPSS 23.0 package program.
Results	The differences before and after badminton training, a statistically significant difference was found between pretest and posttest measurements of flexibility (5.53%), reaction (24.66%), vertical jump (8.93%), and agility (2.54%) tests ($p<0.05$). In the balance test, although there was a mathematical difference of 17.84%, this difference was not statistically significant ($p>0.05$). Finally, 4-week training improves flexibility, reaction, vertical jump and agility performances in a positive and meaningful way ($p<0.05$).
Conclusions	The findings showed that the training method specific to badminton sport improved the flexibility, reaction, vertical jump and agility performances of individuals compared to pre-training. Specifically, these results revealed that the training-performance relationship clearly affects each other positively. In future studies, it can be predicted that more multidisciplinary training methods will be directed to research by making macro plans.

Keywords: badminton, training, biomotoric parameters, blazepod.

Introduction

Besides being an Olympic sport [1], badminton is a popular recreational sport played by 200 million people around the world casually, outdoors, often as a garden or beach game [1, 2].

One of the fastest racquet sports in the world, badminton is highly competitive and dynamic [3, 4] it is also defined as a versatile, explosive sprint sport that requires players to perform intense rhythmic movements [5]. From this point of view, due to the rapid use of the racket and the high frequency of strokes, the player must have good running, acceleration, deceleration, jumping, lunge, change of direction and reflex skills [4, 6]. On the other hand, badminton, a technical sport that requires the development of motor coordination and sophisticated racket movement at elite levels of play, it is important to develop a combination of factors such as muscle strength, muscular endurance, aerobic endurance, agility, power, speed, flexibility, balance, decision making and reflex, which are important for players. The fact that all these factors are very good will bring along the perfect condition, which is important for the players throughout the match. It is known that badminton poses great challenges for players and coaches of all levels, as it is a very complex and multi-talented sport. Therefore, it is a versatile sport that requires a combination of technical and tactical skills, physical and physiological fitness, as well as psychological strength [2, 3, 7-9].

While badminton requires anaerobic energy expenditure for dynamic motor activities such as starting, changing direction, fast and powerful hitting with the shuttlecock, jumping and jumping, it requires aerobic energy expenditure from the duration of the game and to perform repetitive movement sequences [10]. In addition, classification of racquet sports such as table tennis, badminton, tennis and squash as reaction sports highlights excellent eye, hand, foot and ball coordination [6, 11]. This is directly related to visual reaction time and motor response speed. Reaction time is affected by many factors such as age, gender, number of simultaneous stimuli, nutrition, physical activity, training, physical fitness and fatigue [11].

Therefore, the physical and physiological fitness of the players can be a determinant of success in a tournament, so if players want to perform well and achieve success, they must make advanced

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improvements in physical fitness [7, 9]. Therefore, all of the components that make up the conditioning should form part of the training. Because the player must perform various movements such as running, stopping suddenly and moving quickly, jumping, reaching, turning quickly and taking wide steps, which the player does repeatedly and for a long time, without losing his balance [9]. For example, multiplying training modalities to increase leg strength allows the player to move quickly and abruptly in various directions and make high jumps [7]. In this respect, the aim of our study is; to investigate the effectiveness of 4-week badminton training on some selected biomotoric features in young individuals engaged in recreational sports.

Material and Methods

Participants

A total of 27 students (age 18.85±0.98 years) from the faculty of sports sciences who had no health problems and had never played badminton before were included in the study. If they had a history of health problems, a disease or physical condition that could affect physical activity, they were excluded from the study. All of the participants were previously informed about the testing procedures and any known risks, and provided their own written informed consent. Participants were asked not to do any exercise 24 hours before the tests. All of the procedures were in accordance with the Helsinki Declaration of 2021. This study was approved by University of Inonu Ethics Committee for research on human participants.

Research Design

After the demographic and biometric information of the individuals participating in the research were obtained, the performance tests (flexibility, balance, jump, reaction and agility) were measured before the training program. Then, after a 1-week adaptation period, the individuals started badminton-specific training (table 1) for a total of 4 weeks, 60 minutes a day, 2 days a week. After the training program was over, the same tests applied before the training were applied after the training. All tests were administered in the indoor gym of the faculty of sports sciences. All the data obtained were recorded on the form created specifically for the study.

Height and Body Mass

All measurement procedures were performed without minimal clothing and shoes. The height measurements of the participants were measured with a 0.1 cm precision portable stadiometer (Seca Ltd., Bonn, Germany) with the head in the frankfort plane, while the body was upright and the weight was evenly distributed on both legs. Body weight (VA) and body fat ratio measurements were measured with a body analyzer with a capacity of 270 kg and a sensitivity of 100 g (Tanita SC-330S, Amsterdam, Netherlands).

Test Protocols

T Agility Test

The T-Drill is a test of agility and includes forward-backward and left-right running, and measures the ability for defensive movements and speed with directional changes.

Each subject was required to sprint forward 9 m and touch the tip of the cone with the right hand. Then she performed a lateral shuffle to the left 4.5 m, and touched the tip of the cone with the left hand. Subject then changed direction and shuffled 9 m to the right to touch the tip of the cone with her right hand. She then shuffled 4.5 m to the left to touch the tip of the cone in the middle with her right hand. Finally, the subject back-peddled 9 m, passing through the finish point. 3 trial rights were given for each athlete. The subjects were allowed 3 minutes of rest between each run. By writing the measurement results in seconds, the best time obtained in three trials was recorded. Any subject who crossed one foot in front of the other, failed to touch the tip of the cone, and/or failed to face forward throughout had to repeat the test [12-14].

Balance Test

The flamingo balance test measures the ability to balance successfully on a single leg. In the flamingo test, a wooden or metal beam whose body is 50cm long, 4cm high and 3cm wide and the dimensions of the support legs that provide the stability of this beam are applied using a tool that is 15cm long and 2cm wide. Participants should bend their free leg back and grasp their back foot with the same hand and stand for 1 min. Participants are given a trial first to familiarize themselves with the test. The timekeeper helped the participant get into the right position and started timing when the subject released the timekeeper's hand. Then the number of attempts needed to stand on one leg for 1 min is counted for each leg. The result was the maximum number of attempts in 1 min, which was limited to 30. If the subject exceeded this number 15 times in the first 30 s, the subject's result was 31 [15, 16].

Sit and Reach Test

Flexibility was measured using a sit-and-reach test, using a sit-and-reach box (Baselıne/ Fabrication Enterprises, Inc., PO Box 1500, White Plains, NewYork). The subjects sat with their feet approximately hip-wide against the testing box. For the test performance, the subjects was placed seated on the floor with the legs stretched, barefooted, and with the soles of the foot attached to the Seat and Reach case. They kept their knees extended and placed the right hand over the left, and slowly reached forward as far as they could by sliding their

Table 1. Training program

Weeks	Days	Times	Content of the training
1. Week	Tuesday	60 min.	10 min. Badminton game and material presentation 10 min. Warming 20 min. Teaching the basic stance and racket grip [fhd and bkhd] 15 min. Badminton-specific educational game 5 min. Cooling and stretching
	Friday	60 min.	10 min. Warming 10 min. Repeating the basic stance and racquet grip 15 min. Ball bounce exercises [fhd and bkhd] 20 min. Service training and studies 5 min. Cooling and stretching
2. Week	Tuesday	60 min.	10 min. Warming 10 min. Repetition of training and practice of service shots [fhd and bkhd] 25 min. 1, 2 and 3 runway shadow work 10 min. Educational game for stepping development 5 min. Cooling and stretching
	Friday	60 min.	10 min. Warming 10 min. Repeating the running track shadow work 1, 2 and 3 25 min. 4 and 5 runway shadow work 10 min. Educational game for stepping development 5 min. Cooling and stretching
3. Week	Tuesday	60 min.	10 min. Warming 10 min. Repeating the running track shadow work 4 and 5 25 min. 6, 7 and 8 runway shadow work 10 min. Educational game for stepping development 5 min. Cooling and stretching
	Friday	60 min.	10 min. Warming 20 min. Overhead stroke teaching 15 min. Drive stroke training and exercises 10 min. Educational game for developing headshots 5 min. Cooling and stretching
4. Week	Tuesday	60 min.	10 min. Warming 10 min. Repetition of drive stroke training and exercises [fhd and bkhd] 25 min. Clear kick training and exercises 10 min. Educational game to improve clear hit 5 min. Cooling and stretching
	Friday	60 min.	10 min. Warming 10 min. Repetition of clear stroke training and exercises 25 min. Lob-drop stroke training and exercises 10 min. Educational game to improve lop-drop hit 5 min. Cooling and stretching

*min. = minute; fhd = forehand; bkhd = backhand hands along the measuring board. A tape measure on top of the measuring board indicated in centimeters how far beyond the toes each individual reached. The score [in centimeters] is the greatest distance contacted by the fingertips past the toes. After 2 standard 10-second warm-up stretches, 3 attempts were made and the best score was used [17-19].

Reaction Test

This test was used to determine participants' hand-eye reaction times. The BlazePod™ (Play Coyotta Ltd., Tel Aviv, Israel) instrument developed specifically for this test was used for performance measurement. BlazePod light discs are placed 20 cm apart and 45 cm off center on a hard plate/floor. Participants performed the test with their dominant hand for 30 seconds. During the test, the hand was returned to the starting position after each contact with the light sensors. Before starting the test, participants were allowed to do a pre-test consisting of 5 responses to light stimuli [20, 21].

Vertical Jump

The vertical jump test is a standardized test for measuring explosive power, vertical jump and athletic performance. The vertical jump height indicator (Vertec/by Jump USA) was used for the measurement of this test. At the moment preceding the jump, the participants could freely flex the hip, knee, and ankle joints and prepare the upper limbs for a sudden upward thrust, in an effort to promote the highest vertical jump possible. The participants stands with feet apart below the height indicator. The feet are at shoulder-width. The participants swings his arms forward and up, jumps upward and tries to make contact with the rod of the indicator with his right hand at the position which indicates the highest possible value, lands in the starting position and repeats the jump, only now trying to make contact with the rod of the indicator using his left hand. The rest time between jumps was 20 s. The participant's vertical jump height was calculated as the difference between their maximum jump height and standing reach height. "Peak Power" was calculated from the maximal jump height of three trials [22, 23].

Statistical Analysis

Statistical analyzes of the data obtained as a result of the research were obtained using the "IBM SPSS 23.0 (IBM Corp., Armonk, NY, USA)" package program. After descriptive statistics of the data were made, normality analysis was performed for the data set.

For the homogeneity of the research data, the normal distribution of the data was tested with the "Skewness-Kurtosis" and "Shapiro Wilks" tests. As a result of this test, it was determined that the distributions were normal. Therefore, "Paired Simple T Test", which is one of the parametric tests, was used to analyze the difference between the pre-test and post-test. All tests taken were expressed as median (min-max), mean and standard deviation (SD) values. The degree of significance was determined as "p <0.05" in the study.

Results

Table 2 shows that the average age of the athletes participating in the study was 18.85 ± 0.98 years, an average height of 172.85 ± 7.29 cm, and body weight 62.04 ± 8.83 kg.

Table 2. Descriptive data of all participants

Demographic features	N	$\overline{X}$	SS
Age [years]	27	18.85	0.98
Height [cm]	27	172.85	7.29
Body weight [kg]	27	62.04	8.83

Table 3. Findings of the difference before and after badminton training

		Pre-Test	Post-Test	T Test			
Biomotoric abilities	N	$\overline{X}$±SS	$\overline{X}$±SS	t	p	ES	%Δ
Flexibility	27	37.59±7.04	39.67±6.33	-2.721	.011*	0.031	5.53
Reaction	27	1050.78±89.40	791.59±125.30	10.498	.000**	0.238	24.66
Balance	27	6.22±3.74	5.11±2.77	1.955	.061	0.033	17.84
Vertical Jump	27	45.56±8.12	49.63±9.51	-3.631	.001*	0.046	8.93
Agility	27	9.0352±.89420	8.8070±.8076	2.087	.047*	0.026	2.54

ES: Effect Size; * The difference is statistically significant at the p<0.05 level; ** The difference is statistically significant at the p<0.01 level; %Δ: percentage of difference between measurements

The findings of the Paired Simple T-Test results regarding the analysis of the data in this study are as follows.

In Table 3, according to the results we analyzed for the dependent sample groups, the differences before and after badminton training a statistically significant difference was found between pretest and posttest measurements of flexibility (ES=0.031; p=0.011; 5.53%), reaction (ES=0.238; p=0.000; 24.66%), vertical jump (ES=0.046; p=0.001; 8.93%), and agility (ES=0.026; p=0.047; 2.54%) tests ($p<0.05$).

In the balance test, although there was a mathematical difference of 17.84%, this difference was not statistically significant (ES=0.033; p=0.061) ($p>0.05$).

Discussion

This study aimed to investigate the effect of 4-week badminton training on some biomotoric properties in young individuals who have not played badminton before but play sports recreationally. Although there was little improvement in parameters such as flexibility (5.53%), reaction (24.66%), vertical jump (8.93%) and agility (2.54%) before and after training, this improvement was significant ($p<0.05$). However, although a percentage improvement was observed in the balance (17.84%) parameter, this improvement was not significant ($p>0.05$).

Chong [24], according to the results of the study in which they conducted a pre-post test on the agility of badminton players two days a week for a total of 4 weeks with two different groups, stated that although there was no significant difference between the training group and the control group, the training group made a significant improvement with a few training sessions. Churi and Varadharajulu [8], in their study in which they performed core exercises on badminton players for four weeks, revealed that these exercises showed improvement in strengthening the core region. Sighamoney et al. [25] in their four-week study to investigate the effect of strengthening the core region on dynamic balance and agility, they showed that strengthening the core region has a significant effect on dynamic balance and agility. Wee et al. [2] investigated the effects of multiple shuttle training on aerobic and anaerobic capacity, leg strength and agility. The study lasted for a total of four weeks, divided into two groups as control and training groups. Accordingly, when the pre-test and post-test mean scores were compared, it was determined that there was an improvement in VO2max, average power, leg reactive power and agility parameters in the training group. Dass et al. [5] aimed to evaluate the effectiveness of strengthening and plyometric resistance training on anaerobic power and muscle strength in badminton players. According to the data obtained after 5 weeks of training, they concluded that there was a significant improvement in the post-training values in the comparison made for the training group. Guo et al. [4] designed a 6-week study in which they examined the effect of combined balance and plyometric training on the diversion performance of badminton players. Accordingly, they revealed that combined training can improve the changing performance of badminton players more than plyometric training alone. This study also showed that short-term training models have effects on agility and anaerobic capacity in parallel with the literature. However, the balance parameter did not show any improvement in our study, contrary to the literature. For balance development, training should be arranged in a way that includes longer-term and parameter-specific studies. Based on this, Preeti et al. [6], in their study to evaluate the effectiveness of pilates on lower extremity strength, dynamic balance, agility and coordination skills in badminton players, they made the training and control groups exercise for 60 minutes for 5 weeks, two days a week. Accordingly, they explained that pilates exercises showed a significant improvement in both groups at the end of the 5th week and also showed a significant difference in the training group players. These results showed us that balance studies require longer-term studies. When we examined the reaction studies, Patel and Rathi [11] stated that there was an improvement in the training group compared to the control group, but this was not a statistically significant improvement, according to the results of the exercise they had done twice a day for four weeks for visual reaction time. Our study showed similar improvements in visual and tactile reaction parameters with the literature, but unlike the literature, this improvement was significant. Bhosale et al. [26], in their study in which they looked at the effects of 6-week plyometric training on agility and vertical jump parameters, shows that plyometric training improves jumping and agility performance in badminton players. In this sense, our research has revealed that short-term training provides improvements in vertical jump performance in parallel with the studies carried out. Jan and Yaday [27], in their study to investigate the effect of some training on flexibility and coordination in tennis and badminton players, stated that badminton players developed more flexibility and coordination. In our research, we have shown similar results with the literature and we can say that regular training or exercises improve flexibility.

Conclusions

The study showed that the training method, which is specific to badminton sports and with mixed training planning, improves the flexibility, reaction, vertical jump and agility performances of individuals who do recreational sports, by improving them compared to pre-training. Specifically, these results revealed that the training-performance relationship clearly affects each other positively. In future studies, it can be predicted that more multidisciplinary training methods will be directed to research by making macro plans.

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Conflicts of interest

The authors declare no conflicts of interest.

References

1. Nirendan J, Murugavel K. Effect of Selected Footwork Drills on Motor Fitness Variables of Badminton Players. *Bharathiar Natl J Phys Educ Exerc Sci.* 2019;10(3):1–5. https://doi.org/10.5220/0006501000390047
2. Wee EH, Low JY, Chan KQ, Ler HY. Effects of High Intensity Intermittent Badminton Multi-Shuttle Feeding Training on Aerobic and Anaerobic Capacity, Leg Strength Qualities and Agility. In: *Proc 5th Int Congr Sport Sci Res Technol Support*. 2017;39–47. https://doi.org/10.5220/0006501000390047
3. Savla HN, Sangaonkar M, Palekar T. Correlation of core strength and agility in badminton players. *Int J Appl Res*. 2020;6(12):383–7.
4. Guo Z, Huang Y, Zhou Z, Leng B, Gong W, Cui Y, et al. The Effect of 6-Week Combined Balance and Plyometric Training on Change of Direction Performance of Elite Badminton Players. *Front Psychol*, 2021;12:684964. https://doi.org/10.3389/fpsyg.2021.684964
5. Dass B, Khan M, Hotwani R AS. Impact of strength and plyometrıc traınıng on agılıty, anaerobıc power and core strength ın badmınton players. *J Med Pharm allied Sci.* 2021;10(4):3254–8. https://doi.org/10.22270/jmpas.V10I4.1300
6. Preeti, Kalra S, Yadav J, Pawaria S. Effect of Pilates on Lower Limb Strength, Dynamic Balance, Agility and Coordination Skills in Aspiring State Level Badminton Players. *J Clin Diagnostic Res.* 2019;13(7):1–6. https://doi.org/10.7860/JCDR/2019/41713.12978
7. Ganeshkumar T Senthilkumar PK. Efficacy of specific skill and neuromuscular training on speed and explosive power among badminton players. *Int J Physiol Nutr Phys Educ.* 2009;4(1):1455–7.
8. Churi AB, Varadharajulu G. Effect of core strengthening and conditioning programme on badminton beginners. *Indian J Forensic Med Toxicol.* 2020;14(3): 156-61.
9. Nugroho S, Nasrulloh A, Karyono TH, Dwihandaka R, Pratama KW. Effect of intensity and interval levels of trapping circuit training on the physical condition of badminton players. *J Phys Educ Sport.* 2021;21:1981–7. https://doi.org/10.7752/jpes.2021.s3252
10. Jaworski J, Zak M, Lech G, Bujas P, Zak S, Tchórzewski D. Somatic and functional compensations in junior badminton players. *Hum Mov.* 2018;19(1):26–33. https://doi.org/10.5114/hm.2018.73609
11. Patel B & Rathi P. Effect of 4 week exercise program on visual reaction time. *Int J Phys Educ Sport Heal.* 2019;6(4):143–7.
12. Sassi RH, Dardouri W, Yahmed MH, Gmada N, Mahfoudhi ME, Gharbi Z. Relative and absolute reliability of a modified agility t-test and its relationship with vertical jump and straight sprint. *J Strength Cond Res.* 2009;23(6):1644–51. https://doi.org/10.1519/JSC.0b013e3181b425d2
13. Pauole K, Madole K, Garhammer J, Lacourse M, Rozenek R. Reliability and Validity of the T-Test as a Measure of Agility, Leg Power, and Leg Speed in College-Aged Men and Women. *J Strength Cond Res.* 2000;14(4):443–50. https://doi.org/10.1519/00124278-200011000-00012
14. Garcia-Gil M, Torres-Unda J, Esain I, Duñabeitia I, Gil SM, Gil J, et al. Anthropometric parameters, age, and agility as performance predictors in elite female basketball players. J Strength Cond Res. 2018;32(6):1723–30. https://doi.org/10.1519/JSC.0000000000002043
15. Sember V, Grošelj J, Pajek M. Balance tests in pre-adolescent children: Retest reliability, construct validity, and relative ability. *Int J Environ Res Public Health.* 2020;17(15):1–13. https://doi.org/10.3390/ijerph17155474
16. De Miguel-Etayo P, Gracia-Marco L, Ortega FB, Intemann T, Foraita R, Lissner L, et al. Physical fitness reference standards in European children: The IDEFICS study. *Int J Obes.* 2014;38(2):57–66. https://doi.org/10.1038/ijo.2014.136
17. López-Miñarro PA, Andújar PS de B, Rodríguez-García PL. A comparison of the sit-and-reach test and the back-saver sit-and-reach test in university students. *J Sport Sci Med.* 2009;8(1):116–22.
18. Barbosa RA, Santarém JM, Jacob Filho W, De Fátima Nunes Marucci M. Effects of resistance training on the sit-and-reach test in elderly women. *J Strength Cond Res.* 2002;16(1):14–8. https://doi.org/10.1519/1533-4287(2002)016<0014:EORTOT>2.0.CO;2
19. Carrasco M, Sanz-Arribas I, Martínez-de-Haro V, Cid-Yagüe L y M-G-MI. El test "sit and reach" mide la flexibilidad? Un estudio de casos / Does the "sit and reach" test measures flexibility? A case study. *Rev Int Med y Ciencias la Act Físicay el Deport.* 2013;13(52):749–70.
20. Ergin E, Kartal A. Comparison of Visual Reaction Times of Footballers According to Their Positions. *Akdeniz Spor Bilim Derg.* 2021;4(1):180–92. https://doi.org/10.38021/asbid.910050
21. Zwierko T, Florkiewicz EB, Fogtman S, Kszak-Krzyżanowska A. The Ability To Maintain Attention During Visuomotor Task Performance in Handball Players and Non-Athletes. *Cent Eur J Sport Sci Med.* 2014;7(3):99–106.
22. Stojanović N, Jovanović N, Stojanović T. The effects of plyometric training on the development of the jumping agility in volleyball players. *Facta Univ - Ser Phys Educ Sport.* 2012;10(1):59–73.

23. Yingling VR, Castro DA, Duong JT, Malpartida FJ, Usher JR, Jenny O. The reliability of vertical jump tests between the Vertec and My Jump phone application. *PeerJ.* 2018;4:1–13. https://doi.org/10.7717/peerj.4669
24. Chong YQ. *Effects of ımagery training on agility among male recreational college badminton players.* [PhD Thesis]. Bachelor of Science (Honours) in Sports and Exercise Science, Tunku Abdul Rahman University College; 2018.
25. Sighamoney R, Kad R, Yeole UL. Effect of core strengthening on dynamic balance and agility in badminton players. *Int J Phys Educ Sport Heal*, 2018;5(1):86–8.
26. Bhosale N, Yeole U & Chavarkar M. Effect of Plyometric Training on Jumping Performance and Agility in Badminton Players. *Indian J Public Heal Res Dev.* 2020;11(6):532–7. https://doi.org/10.15314/tsed.319749
27. Jan M, Yaday J. A comparative study on effect of selected exercises on flexibility and co-ordination of badminton and tennis players. *Int J Phys Educ Sport Heal.* 2017;4(3):139–42.

Information about the author:

Nurkan Yılmaz; https://orcid.org/0000-0002-8845-7093; nurkan.yilmaz@inonu.edu.tr; Department of Physical Education and Sports Teaching, Inonu University; Malatya, Turkey.

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PHYSICAL EDUCATION OF STUDENTS

ORIGINAL ARTICLE

Association between physical activity and sleep quality in Algerian adults during COVID-19 lockdown

Adda Oudjedi[ABCDE], Mohamed Derouiche[ABCDE], Abdelghani Allali[ABCDE], Ridha Malek[ABDE], Zoubir Latreche[ABDE]

Institute of Science and Techniques of Physical and Sport Activities, Larbi Ben M'hidi University, Algeria

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim There is no doubt that the Coronavirus disease (COVID-19) pandemic, and its related containment measures such as lockdown and social distancing, is affecting physical activity and sleep quality of the general population worldwide. Algeria, one of the most affected countries in Africa, entered the lockdown on March 9, 2020. Numerous studies have explored the interaction between physical activity and sleep quality showing the effect of physical activity levels on sleep, yet previous researches have not investigated the relationship between physical activity and sleep quality during lockdown.

Material and Methods The main purpose of the present study was to investigate the association between physical activity and sleep quality in quarantined individuals. A national Google online survey was conducted between 16th April and 25th May 2020. 1002 Participants responded to the Pittsburgh Sleep Quality Index (PSQI) questionnaire and the short form of the International Physical Activity Questionnaire (IPAQ). Of the 1002 participants who completed the survey, 358 were students. The final data were collected from the respondents.

Results The COVID-19 home confinement led to a decrease in physical activity levels. However, the majority of the study population had good sleep quality (61.9%), while only (38.1%) had poor sleep quality. In addition, women are less physically active than men ($p < 0.01$). Moreover, there was a significant difference in sleep quality between sufficient and insufficient physical activity groups ($p < 0.05$).

Conclusions Our results show that Algerian adults have low levels of physical activity, good sleep quality, and poor sleep quality is associated with insufficient physical activity in adults during lockdown.

Keywords: adults, sleep quality, Algerian, survey, students.

Introduction

In December 2019, a series of pneumonia cases of unknown cause was recognized in Wuhan, China, with clinical presentations greatly resembling viral pneumonia [1]. The emergence and spread of the novel coronavirus and the related COVID-19 disease is deemed as a major public health threat for almost all countries around the world [2].

Algeria, like other countries through the world, has not escaped this pandemic respiratory disease. The actual situation shows a number of 99 610 positive cases and 2 756 deaths [3]. With the rapid spread of the COVID-19 outbreak globally, the World Health Organization (WHO) has recommended the implementation of public health measures, such as isolation of all individuals suspected of infection with this disease for a 14-day quarantine period, while respective governments have also introduced "social distancing" and "lock-downs" of entire populations of varying severity to mitigate the spread of the pandemic [4]. While these restrictions helped in decreasing the rate of infection, there may also be concomitant negative effects as a result of limiting restricting people's daily activities such as walking and cycling for transport and leisure and access to many types of recreational activities such as team sports, gyms, fitness centers, and dancing classes [5]. In this context, achieving recommended levels of physical activity (PA) is crucial to achieving the physiologic and psychosocial benefits associated with physical activity, and reduce the risk of several chronic diseases. Moreover, physical activity can attenuate the detrimental effects of sedentary behavior and its association with all-cause mortality [6]. Several studies have shown the detrimental effect of COVID-19 on physical activity and sleep quality. An Australian survey of around 1491 participants found that (48.9%) and (40.7%) reported a decrease in PA levels and sleep respectively since the onset of the COVID-19 pandemic [7].

Getting sufficient sleep has also been recommended as insufficient sleep or prolonged sleep deficiency (e.g., short sleep duration, sleep disturbance) can lead to chronic, systemic low-grade inflammation and is associated with various diseases that have an inflammatory component, like obesity, diabetes, cardiovascular diseases, neurodegeneration, and accidents. Sleeping has systematically been found to be related to lower risks

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of morbidity and mortality [8, 9]. More specifically, it is widely accepted that sleep deprivation has detrimental effects on the immune response and may impair the immune system [10]. Within this context, The American Academy of Sleep Medicine (AASM) recommends regular physical activity for proper sleep hygiene. AASM suggests exercise can be a non-pharmacological intervention for sleep quality improvement [11].

We hypothesize that COVID-19 home confinement would negatively affect sleep quality, PA levels of quarantined individuals, and that 'good sleep quality' would be associated with 'sufficient' PA. Therefore, the aims of the present study were to, (I) evaluate the effects of COVID-19 home confinement on sleep patterns and PA levels, and (II) explore the association between PA levels and sleep quality.

Materials and Methods

Participants

The sample consisted of 1002 adults (665 men and 337 women), 18 to 65 years of age from all regions of Algeria were recruited for this study. Of the 1002 participants who completed the survey, **358 were students**.

Google platform was used for an anonymous survey. A link to the survey was distributed using social media (Facebook, Twitter...etc), through websites and emails. The study protocol was approved by the Institutional Review Board of the Faculty of the Institute of sport and exercise science at Oum El Bouaghi University and was conducted following the Declaration of Helsinki.

The inclusion criteria were (1) the minimum age of 18 years, (2) the current residence in Algeria, and (3) the ability to complete the questionnaires in Arabic. Other inclusion or exclusion criteria did not apply.

Research Design

The International Physical Activity Questionnaires Short Form (IPAQ-SF) was used to evaluate the PA level in participants, whose validity and reliability have been tested in 12 countries [12].

It provided information about the time and number of days spent in light, moderate, and vigorous-intensity physical activity. According to the WHO, sufficient physical activity is defined as at least (1) 150 min/week of moderate physical activity or (2) 75 min/week of vigorous physical activity or (3) an equivalent combination of both. Thus, we categorized the participants who met the aforementioned recommendation as sufficiently active compared with the participants who did not meet the recommended levels of physical activity weekly [13].

Based on the IPAQ recommendations for scoring protocol, participants of the study were classified in three different groups based on the MET–min/wk of the sum of walking, moderate-intensity physical activities, and vigorous-intensity physical activities: lowly active (< 600 MET–min/wk); moderately active (600 MET–min/wk ⩽ PA < 3000 MET–min/wk) and highly active (⩾ 3000 MET–min/wk) [14].

The sleep quality was assessed by the Pittsburgh Sleeping Quality Index Questionnaire (PSQI). It is 19 self-reported questions that examine one of the seven components of sleep quality components: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep medication intake, and daytime dysfunction. Each component score was rated on a 3-point scale with higher scores denote poor sleep, leading to a sum of up to 21 points. PSQI scores > 5 and ⩽ 5 indicated poor and good sleep quality, respectively [15] . It has been reported that The Arabic PSQI has an acceptable internal consistency reliability of the global PSQI (0.70) among 35 healthy Arabic participants [16].

A cross-sectional study was conducted in a convenience sample of the general population in Algeria by using online surveys. 1002 participants (665 men and 337 women, aged 18–65 years) provided full data.

Participants self-reported their height in meters (m) and weight in kilograms (kg), from which body mass index (kg/m2) was calculated. Data about demographics, physical activity, and sleep patterns were collected.

Participants completed the online survey, after reading the written consent form and explicitly agreeing to participate in the survey. The online survey was conducted between 16th April 2020 to 25th May 2020, with a total of 1002 respondents.

Statistical Analysis

Statistical analyses were performed using the commercial software "Statistical Package for the Social Sciences" (SPSS for Windows, version 20.0, SPSS Inc., Chicago, Illinois, USA) and the level of significance was set at $p < 0.05$. Using the Kolmogorov-Smirnov test, the normality of the data distribution was not confirmed.

Basic descriptive statistics of the study participants are presented as frequencies (n) and percentages (%). The Chi-Square test was used to compare physical activity levels and sleep quality between men and women. Furthermore, to analyze Sleep characteristics according to the level of physical activity, participants were split into sufficiently active and insufficiently active groups and comparative analysis was conducted by using Chi-Square (c2). Lastly, the associations between physical activity and sleep quality domains were assessed by Pearson correlation analysis.

Results

Our study sample consisted of 1002 participants: 337 (33.6%) females and 665 (66.4 %) males. There were no missing data. Gender, age, and employment status are presented in Table 1. In general, most participants are employed for wages and students.

Table 1. Demographic characteristics of the participants.

Variables	N	%
Gender		
Males	665	66.36 %
Females	337	33.63 %
Age		
18-30	525	52.39 %
30-40	335	33.43 %
40-50	116	11.57 %
50-60	26	2.59 %
Employment status		
Student	**358**	**35.72 %**
Employed for wages	459	45.80 %
Trainee	14	1.39 %
Self-employed	61	6.08 %
Out of work/Unemployed	100	9.98 %
Retired	10	0.99 %

In Table 2, we show the patterns of sleep quality, physical activity, and body mass index according to the participants' gender. The BMI was calculated from the reported weight and height of each participant, and it was found that (3.8%) of participants were considered underweight, while (54%) had normal BMI and (42.1%) were Overwight/ obese.

The majority of participants had light PA (63.07%) and female participants had a significantly lower prevalence of light, moderate and vigorous PA levels than males ($p < 0.01$). Moreover, two-thirds of study participants (61.9%) were good sleepers, compared with (38.1%) of the sample who reported having poor sleep quality. In addition, there were significant differences in Subjective sleep quality ($p < 0.01$), Sleep latency (p=0 , 029), Sleep efficiency (p= 0, 029) , Sleep disturbances (p < 0, 01) , Daytime dysfunction (p < 0, 01) and Sleep quality ($p < 0.01$). However, there were no differences or associations with gender were observed for sleep duration and Use of sleep medication.

The prevalence of sleeping characteristics according to the level of physical activity among the study participants is presented in Table 3. Sleep quality differed significantly according to participants' physical activity level (p =0, 039). Among the respondents, 64.4% of the physically active group reported having good sleep quality, while only 35.6% reported having poor sleep quality. However, 57.9 % enjoying good sleep quality, while 42.1% have poor sleep quality. In addition, there were significant differences in BMI status (Normal, Overweight /Obesity) ($p < 0.05$).

Table 4 shows the relationships (person's correlation) between all variables included in the analyses. Particularly, total score of PSQI was not significantly associated with the global score of PA ($P > 0.05$).

Discussion

The present study examined the association between physical activity and sleep quality among Algerian adults during the COVID-19 pandemic.

The major insight of our study about sleep quality was that the majority of the study population had good sleep quality (61.9%), while only (38.1%) had poor sleep quality. Our results seem to reflect that the changes under mobility restrictions and lockdown might have benefited sleep quality in our population. These findings are somewhat surprising given the fact that other research shows that sleep quality was markedly impaired [6, 17, 18]. However, our results are consistent with those of [19] who found no significant differences in sleep parameters.

Overall, the majority of participants reported having light or low physical activity levels during mobility restriction and home confinement. Our findings confirmed that the lockdown had a negative impact on PA levels, as it was initially expected. Being confined at home imposed a structural barrier to maintaining a physically active lifestyle [20].

Our results showed that women are less physically active than men. An analysis published in The Lancet Global Health, in 2018, found that across most countries, women are less active than men (global average of 31·7% for inactive women vs 23·4% for inactive men) [21]. In addition, a positive relationship between individuals sufficiently active and sleep quality was found. Our findings are consistent with previous studies [8, 22, 23]. It has been shown that physically active individuals had good sleep quality compared with those individuals with insufficient physical activity levels [13].

A meta-analysis of randomized trials conducted on the effect of an exercise program on sleep quality suggested that physical activity could become an alternative non-pharmacological therapy for those who are complaining of sleep problems due to its moderately positive effect on total sleep duration, slow-wave sleep, and sleep onset latency [24]. In addition, physical exercise, the especially moderate exercise showed a more promising outcomes on sleep quality than vigorous exercise [22].

The low prevalence of adequate PA levels is a main contributing factor to the high prevalence of overweight and obesity [25]. Overweight and obese individuals are more likely to have respiratory symptoms than individuals with a normal BMI, even in the absence of demonstrable lung disease [26].

In a recent meta-analysis, Banno and his colleagues showed that the exercised group

Table 2. Characteristics of the study participants, stratified by gender

Study variables	Total sample(1002)	Men Numbers (percentage%)	Women Numbers (percentage%)	c2 P- value
1/ Subjective sleep quality				
Very good	140	104 (15.6 %)	36 (10.7 %)	
Fairly good	410	294 (44.2 %)	116 (34.4 %)	25.009
Fairly bad	223	201 (30.2 %)	122 (36.2 %)	0.000 **
Very bad	129	66 (9.9 %)	63 (18.7 %)	
2/Sleep latency (min)				
⩽15	235	167 (25.1 %)	68 (20.2 %)	
16–30	363	249 (37.4 %)	114 (33.8 %)	8.992
31–60	266	170 (25.6 %)	96 (28.5 %)	0.029 *
>60	138	79 (11.9 %)	59 (17.5 %)	
3/Sleep duration(hours)				
>7	371	239 (35.9 %)	132 (39.2 %)	
6–7	399	268 (40.3 %)	131 (38.1 %)	2.670
5–6	130	84 (12.6 %)	46 (13.6 %)	0.445
<5	102	74 (11.1 %)	28 (8.3 %)	
4/sleep efficiency (%)				
>85%	497	352 (52.9 %)	145 (43.0 %)	
75–84%	188	118 (17.7 %)	70 (20.8%)	9.020
65–74%	129	81 (12.2 %)	48 (14.2 %)	0.029*
<65%	188	114 (17.1 %)	74 (22.0 %)	
5/Sleep disturbances				
0	121	88 (13.2 %)	33 (9.8 %)	
<1/week	713	493 (74.1 %)	220 (65.3 %)	24.986
1–2/week	161	80 (12.0 %)	81 (24.0 %)	0.000**
⩾3/week	07	4 (0.6 %)	3 (0.9%)	
6/Use of sleep medication				
0	890	588 (88.4%)	302 (89.6 %)	
<1/week	58	42 (6.3 %)	16 (4.7 %)	2.121
1–2/week	27	17 (2.6 %)	12 (3.6 %)	0.548
⩾3/week	25	18 (2.7 %)	7 (2.1 %)	
7/Daytime dysfunction				
Not a problem	329	253 (38 %)	76 (22.6 %)	
Fairly a problem	471	300 (45.1 %)	171 (50.7 %)	30.117
Problem	161	86 (12.9 %)	75 (22.3 %)	0.000**
Very big problem	41	26 (3.9 %)	15 (4.5 %)	
8/Sleep quality				
Good	620	382 (57.4 %)	238 (70.6 %)	16.469
Poor	382	283 (42.6 %)	99 (29.4 %)	0.000**
9/ Physical activity				
Light	632	400 (60.2 %)	232 (68.8 %)	
Moderate	180	136 (20.5 %)	44 (13.1 %)	9.686 0.008**
vigorous	190	129 (19.4 %)	61 (18.1 %)	
10/Body mass index				
underweight	38	15 (2.3 %)	23 (6.8 %)	
Normal	542	356 (53.5%)	186 (55.2 %)	14.487 0.001**
Overweight /Obesity	422	294 (44.2 %)	128 (38.0 %)	

Note. *p < .05, **p < .01.

Table 3. Sleep quality index according to the level of physical activity in the study participants.

Study variables	**Total sample (n=1002)**	**sufficient physical activity**	**insufficient physical activity**	**c2 P- value**
1/ Subjective sleep quality				
Very good	140	74 (12 %)	66 (17.1 %)	5.794
Fairly good	410	251 (40.8 %)	159 (41.1 %)	0.122
Fairly bad	323	208 (33.8 %)	115 (29.7 %)	
Very bad	129	82 (13.3 %)	47 (12.1 %)	
/2 Sleep latency (min)				
⩽15	235	139 (22.6 %)	96 (24.8 %)	
16–30	363	225 (36.6 %)	138 (35.7 %)	
31–60	186	164 (26.7 %)	102 (26.4 %)	0.719
>60	129	78 (14.1 %)	51(13.2 %)	0 .869
3/Sleep duration(hours)				
>7	371	219 (35.6 %)	152 (39.3 %)	
6–7	399	249 (40.5 %)	150 (38.8 %)	
5–6	130	84 (13.7 %)	46 (11.9 %)	1.622
<5	102	63 (10.2 %)	39 (10.1 %)	0.654
4/sleep efficiency (%)				
>85%	497	296 (48.1 %)	201 (51.9 %)	
75–84%	188	120 (19.5 %)	68 (17.6%)	2.801
65–74%	129	76 (12.4 %)	53 (13.7 %)	0.423
<65%	188	123 (20.0 %)	65(16.8 %)	
5/Sleep disturbances				
0	121	78 (12.7 %)	43 (11.1 %)	
<1/week	713	425 (69.1 %)	288 (74.4 %)	3.481
1–2/week	161	107 (17.4 %)	54 (14.0 %)	0.323
⩾3/week	07	5 (0.8 %)	2 (0.5%)	
6/Use of sleep medication				
0	890	543 (88.3%)	347 (89.7 %)	
<1/week	58	32 (5.2 %)	26 (6.7 %)	
1–2/week	29	24 (3.9 %)	5 (1.3 %)	6.657
⩾3/week	24	16 (2.6 %)	9 (2.3 %)	0.084
7/Daytime dysfunction				
Not a problem	329	197 (32 %)	132 (34.1 %)	
Fairly a problem	471	284 (46.2 %)	187 (48.3 %)	
Problem	161	108 (17.6 %)	53 (13.7 %)	2.825
Very big problem	41	26 (4.2 %)	15 (3.9 %)	0.419
8/Sleep quality				
Good	620	396 (64.4 %)	224 (57.9 %)	4.266
Poor	382	219 (35.6 %)	163 (42.1 %)	0.039*
9/ Gender				
Men	665	400 (65%)	265 (68.5 %)	1.255
Women	337	215 (35 %)	122 (31.5 %)	0.263
10/Body mass index				
Normal	542	314 (51.1%)	228 (58.9 %)	5.220
≠				
Overweight /Obesity	422	275 (44.7 %)	147 (38.0 %)	0.015*

Note. *p < .05 .

Table 4. Correlation coefficients between the study variables.

Study variables	1	2	3	4	5	6	7	8	9	10	11
Subjective sleep quality	1										
Sleep latency (min)	.353**	1									
Sleep duration (hours)	-.273**	-.093**	1								
sleep efficiency (%)	-.078*	-.205**	.266**	1							
Sleep disturbances	.261**	.296**	-.075*	-.102**	1						
Use of sleep medication	.129**	.118**	-.036	.021	.193**	1					
Daytime dysfunction	.315**	.146**	-.098**	-.074*	.311**	.173**	1				
Sleep quality	.635**	.601**	-.551**	-.404**	.460**	.357**	.512**	1			
Physical activity (minutes)	-.067*	-.001	.014	.019	-.023	-.023	-.037	-.050	1		
BMI	-.017	-.021	-.117**	-.009	.049	.012	-.076*	.018	-.019	1	
Gender	.152**	.092**	.042	-.098**	.168**	-.011	.144**	.144**	-.066*	-.085**	1

Note. *p < .05, **p < .01.

decreased up to 3 points in the Pittsburgh Sleep Quality Index, and 3.22 points in the Insomnia Severity Index when compared with the control group. A slight increase in daily physical levels is an effective strategy to improve sleep duration and decrease sleep latency [27].

In adults, a high level of body mass index (BMI) is related to numerous physiological changes in lung function, regardless of asthma such as a decrease in functional residual capacity (FRC) and expiratory reserve volume (ERV). In addition, there is a moderate reduction in total lung capacity(TLC), vital lung capacity (VLC), and residual volume (RV) in obese individuals with a BMI ⩾ of 30 compared to normal-weight individuals [28]. In patients with increased abdominal obesity, pulmonary function is further compromised in supine patients by decreased diaphragmatic excursion, making ventilation more difficult. Furthermore, increased inflammatory cytokines associated with obesity may contribute to the increased morbidity associated with obesity in COVID-19 infections [29].

Another line of reasoning indicates that regular physical exercise exerts beneficial effects on sleep by acting on factors that can compromise sleep quality, such as obesity [30]. Recently, the European CBT-I Academy published practical recommendations for improving sleep problems during the COVID-19 outbreak, in which they recommend physical exercise, especially in the daylight, as a tool to sleep better [31]. However, the lack of significant association between sleep disturbances and insufficient physical activity could be explained by using self-reports to assess the level of physical activity and sleep disturbances, which might have led to different perceptions and method biases. It was highly suggested that regular moderate-intensity exercise program improves self-rated sleep quality in older adults with moderate sleep complaints [32].

As shown in Table 4, the statistical test obtained a correlation coefficient (R= -0.05) with P > 0.05, so it can be stated that there is no significant relationship between that total score of PSQI and global PA levels score during lockdown. Although, these results differ from some previously published studies [33, 34], they are consistent with those of [35, 36].

Limitations

There are some limitations that need to be considered in our study. First, the cross-sectional study design does not allow to establish causal inferences, so future well-designed longitudinal studies are needed in order to clarify causality. Second, we did not use any objective measurement for the evaluation of PA levels and sleep quality. Therefore, differentiating between the effects of physical activity and exercise on sleep quality was difficult due to the lack of information in the questionnaire to conclude if the exposure was physical activity or exercise. Moreover, validation studies of self-reported sleep show evidence of systematic bias as responses often lead to overestimation of the amount of sleep compared to the measurement made by using actigraphy [37]. Third, the understanding of questionnaires is dependent on other individual and environmental characteristics as socioeconomic status, age, and seasonal variation [38]. In addition, daily naps, are not assessed by the PSQI questionnaire [34]. Therefore, to avoid incorrect generalisations and confirm a causal relationship between PA level and sleep quality, future studies using objective measures should be warranted.

Conclusions

In conclusion, Algerian adults are prone to low levels of physical activity and good sleep quality during lockdown. Furthermore, poor sleep quality is associated with insufficient physical activity.

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Disclosure statement

No potential conflict of interest was reported by the authors.

References

1. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet Lond Engl.* 2020;395(10223):497– 506. https://doi.org/10.1016/S0140-6736(20)30183-5
2. Han J, Qian K, Song M, Yang Z, Ren Z, Liu S, et al. An Early Study on Intelligent Analysis of Speech Under COVID-19: Severity, Sleep Quality, Fatigue, and Anxiety. *Interspeech 2020, ISCA*; 2020. P. 4946–50. https://doi.org/10.21437/Interspeech.2020-2223
3. *Coronavirus 2019* [Internet]. 2021 [cited 2021 Jan 1]. Available from: http://www.sante.gov.dz/coronavirus/coronavirus-2019.html
4. Rubin GJ, Wessely S. The psychological effects of quarantining a city. *BMJ*, 2020:m313. https://doi.org/10.1136/bmj.m313
5. Kontsevaya AV, Mukaneeva DK, Myrzamatova AO, Okely AD, Drapkina OM. Changes in physical activity and sleep habits among adults in Russian Federation during COVID-19: a cross-sectional study. *BMC Public Health*, 2021;21:893. https://doi.org/10.1186/s12889-021-10946-y
6. Luciano F, Cenacchi V, Vegro V, Pavei G. COVID-19 lockdown: Physical activity, sedentary behaviour and sleep in Italian medicine students. *European Journal of Sport Science*, 2021;21:1459–68. https://doi.org/10.1080/17461391.2020.1842910
7. Stanton R, To QG, Khalesi S, Williams SL, Alley SJ, Thwaite TL, et al. Depression, Anxiety and Stress during COVID-19: Associations with Changes in Physical Activity, Sleep, Tobacco and Alcohol Use in Australian Adults. *Int J Environ Res Public Health.* 2020;17:4065. https://doi.org/10.3390/ijerph17114065
8. Chennaoui M, Arnal PJ, Sauvet F, Léger D. Sleep and exercise: A reciprocal issue? *Sleep Med Rev.* 2015;20:59–72. https://doi.org/10.1016/j.smrv.2014.06.008
9. Besedovsky L, Lange T, Haack M. The Sleep-Immune Crosstalk in Health and Disease. *Physiol Rev.* 2019;99(3):1325–80. https://doi.org/10.1152/physrev.00010.2018
10. Bryant PA, Trinder J, Curtis N. Sick and tired: does sleep have a vital role in the immune system? *Nat Rev Immunol.* 2004;4(6):457–67. https://doi.org/10.1038/nri1369
11. Sateia MJ, Buysse DJ, Krystal AD, Neubauer DN, Heald JL. Clinical Practice Guideline for the Pharmacologic Treatment of Chronic Insomnia in Adults: An American Academy of Sleep Medicine Clinical Practice Guideline. *Journal of Clinical Sleep Medicine*, 2017;13:307–49. https://doi.org/10.5664/jcsm.6470
12. Craig CL, Marshall AL, Sjöström M, Bauman AE, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity: *Medicine & Science in Sports & Exercise*, 2003;35:1381–95. https://doi.org/10.1249/01.MSS.0000078924.61453.FB
13. Štefan L, Sporiš G, Krističević T, Knjaz D. Associations between sleep quality and its domains and insufficient physical activity in a large sample of Croatian young adults: a cross-sectional study. *BMJ Open*. 2018;8(7):e021902. https://doi.org/10.1136/bmjopen-2018-021902
14. *International Physical Activity Questionnaire* [Internet]. [cited 2021 Jan 9]. Available from: https://sites.google.com/site/theipaq/
15. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213. https://doi.org/10.1016/0165-1781(89)90047-4
16. Suleiman KH, Yates BC, Berger AM, Pozehl B, Meza J. Translating the Pittsburgh Sleep Quality Index Into Arabic. *West J Nurs Res.* 2009;32(2):250–68. https://doi.org/10.1177/0193945909348230
17. Cellini N, Conte F, De Rosa O, Giganti F, Malloggi S, Reyt M, et al. Changes in sleep timing and subjective sleep quality during the COVID-19 lockdown in Italy and Belgium: age, gender and working status as modulating factors. *Sleep Med.* 2021;77:112–9. https://doi.org/10.1016/j.sleep.2020.11.027
18. Pinto J, van Zeller M, Amorim P, Pimentel A, Dantas P, Eusébio E, et al. Sleep quality in times of Covid-19 pandemic. *Sleep Med*. 2020;74:81–5.

https://doi.org/10.1016/j.sleep.2020.07.012
19. da Silva Santos AM, Rossi FE, dos Santos Nunes de Moura HP, de Sousa Junior AVM, Machado DCD, Neves LM, et al. COVID-19 pandemic impacts physical activity levels and sedentary time but not sleep quality in young badminton athletes. *Sport Sci Health*, 2021;17:969–77. https://doi.org/10.1007/s11332-021-00763-6
20. Martínez-de-Quel Ó, Suárez-Iglesias D, López-Flores M, Pérez CA. Physical activity, dietary habits and sleep quality before and during COVID-19 lockdown: A longitudinal study. *Appetite*, 2021;158:105019. https://doi.org/10.1016/j.appet.2020.105019
21. The Lancet Public Health. Time to tackle the physical activity gender gap. *Lancet Public Health,* 2019;4(8): e360. https://doi.org/10.1016/S2468-2667(19)30135-5
22. Wang F, Boros S. The effect of physical activity on sleep quality: a systematic review. *Eur J Physiother*. 2021;23(1):11–8. https://doi.org/10.1080/21679169.2019.1623314
23. Dolezal BA, Neufeld EV, Boland DM, Martin JL, Cooper CB. Interrelationship between Sleep and Exercise: A Systematic Review. *Advances in Preventive Medicine*, 2017;2017:1–14. https://doi.org/10.1155/2017/1364387
24. Mahfouz MS, Ali SA, Bahari AY, Ajeebi RE, Sabei HJ, Somaily SY, et al. Association Between Sleep Quality and Physical Activity in Saudi Arabian University Students. *Nat Sci Sleep*. 2020;12:775–82. https://doi.org/10.2147/NSS.S267996
25. Kontsevaya A, Shalnova S, Deev A, Breda J, Jewell J, Rakovac I, et al. Overweight and Obesity in the Russian Population: Prevalence in Adults and Association with Socioeconomic Parameters and Cardiovascular Risk Factors. *Obes Facts*. 2019;12(1):103–14. https://doi.org/10.1159/000493885
26. Zammit C, Liddicoat H, Moonsie I, Makker H. Obesity and respiratory diseases. *Int J Gen Med*. 2010;3:335–43. https://doi.org/10.2147/IJGM.S11926
27. Diniz TA, Christofaro DGD, Tebar WR, Cucato GG, Botero JP, Correia MA, et al. Reduction of Physical Activity Levels During the COVID-19 Pandemic Might Negatively Disturb Sleep Pattern. *Front Psychol*. 2020;11: 3356. https://doi.org/10.3389/fpsyg.2020.586157
28. Farzan S. The Asthma Phenotype in the Obese: Distinct or Otherwise? *Journal of Allergy*, 2013;2013:1–8. https://doi.org/10.1155/2013/602908
29. Dietz W, Santos-Burgoa C. Obesity and its Implications for COVID-19 Mortality. *Obesity*. 2020;28(6):1005–1005. https://doi.org/10.1002/oby.22818
30. *SciELO - Brazil - Sleep quality and its associations with leisure-time exercise and excess weight among civil servants Sleep quality and its associations with leisure-time exercise and excess weight among civil servants* [Internet]. 2021 [cited 2021 Aug 2]. Available from: https://www.scielo.br/j/rbcdh/a/V66qZZzVBJWVhkGVgJP3thq/?lang=en
31. Altena E, Baglioni C, Espie CA, Ellis J, Gavriloff D, Holzinger B, et al. Dealing with sleep problems during home confinement due to the COVID-19 outbreak: Practical recommendations from a task force of the European CBT-I Academy. *J Sleep Res*. 2020;29(4): e13052. https://doi.org/10.1111/jsr.13052
32. King AC, Oman RF, Brassington GS, Bliwise DL, Haskell WL. Moderate-Intensity Exercise and Self-rated Quality of Sleep in Older Adults: A Randomized Controlled Trial. *JAMA*. 1997;277(1):32–7. https://doi.org/10.1001/jama.277.1.32
33. Ammar A, Trabelsi K, Brach M, Chtourou H, Boukhris O, Masmoudi L, et al. Effects of home confinement on mental health and lifestyle behaviours during the COVID-19 outbreak: Insight from the ECLB-COVID19 multicenter study. *Biology of Sport*, 2021;38:9–21. https://doi.org/10.5114/biolsport.2020.96857
34. Trabelsi K, Ammar A, Masmoudi L, Boukhris O, Chtourou H, Bouaziz B, et al. Globally altered sleep patterns and physical activity levels by confinement in 5056 individuals: ECLB COVID-19 international online survey. *Biol Sport*. 2021;38(4):495–506. https://doi.org/10.5114/biolsport.2021.101605
35. Cavalcante MV, Siqueira RCL, Costa RC, Lima TF, Costa TM, Costa CLA. Associations between physical activity and sleep quality in the pandemic context of social distancing. *Res Soc Dev*. 2021;10(1):e8610111471. https://doi.org/10.33448/rsd-v10i1.11471
36. Mitchell JA, Godbole S, Moran K, Murray K, James P, Laden F, et al. No Evidence of Reciprocal Associations between Daily Sleep and Physical Activity. *Med Sci Sports Exerc*. 2016;48(10):1950–6. https://doi.org/10.1249/MSS.0000000000001000
37. Kim M. Association between Objectively Measured Sleep Quality and Obesity in Community-dwelling Adults Aged 80 Years or Older: A Cross-sectional Study. *J Korean Med Sci*, 2015;30:199. https://doi.org/10.3346/jkms.2015.30.2.199
38. Wendt A, Flores TR, Silva ICM, Wehrmeister FC. Association of physical activity with sleep health: A systematic review. *Rev Bras Ativ Fís Saúde*, 2019;23:1–26. https://doi.org/10.12820/rbafs.23e0057

Information about the authors:

Adda Oudjedi; (Corresponding author); Lecturer in sport and exercise science ; https://orcid.org/0000-0002-6632-2315; adda.oudjedi@univ-oeb.dz; Institute of Science and Techniques of Physical and Sport Activities; Larbi Ben M'hidi University, B.P. 358 Route de Constantine, 04000 Oum El Bouaghi, Algeria.

Mohamed Derouiche; lecturer in sport and exercise science ; https://orcid.org/0000-0001-6723-0386; istsmohamed@hotmail.fr; Institute of Science and Techniques of Physical and Sport Activities; Larbi Ben M'hidi University, Oum El Bouaghi, Algeria.

Abdelghani Allali; lecturer in sport and exercise science; https://orcid.org/0000-0002-3931-2250; allali.ghani@univ-oeb.dz; Institute of Science and Techniques of Physical and Sport Activities; Larbi Ben M'hidi University, Oum El Bouaghi, Algeria.

Redha Malek; lecturer in sport and exercise science; https://orcid.org/0000-0003-2953-8253; ridha.malek@univ-oeb.dz; Institute of Science and Techniques of Physical and Sport Activities; Larbi Ben M'hidi University, Oum El Bouaghi, Algeria.

Zoubir Latreche; lecturer in sport and exercise science; https://orcid.org/0000-0003-1759-4397; zoubir_l@yahoo.fr; Institute of Science and Techniques of Physical and Sport Activities; Larbi Ben M'hidi University, Oum El Bouaghi, Algeria.

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ORIGINAL ARTICLE

The effect of plyometric training on competition period muscle damage in amateur footballers

Tayfun Şirin[ABCDE]

Department of Coaching Education, Faculty of Sport Science, Kahramanmaras Sutcu Imam Universty, Turkey

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim The aim of this study is to investigate the effect of plyometric training on the damage muscle in amateur footballers.

Material and Methods The research group consists of 19 footballers with an average age of 23.41 ± 3.2. In addition to football training, the research group received a plyometric training program from the third week of the preparation period (two days a week) to the sixth week of the competition period (one day a week). Blood samples were taken in the sixth week of the competition period, before and after the training and on the day of the competition. CK activity was determined in sera obtained from centrifuged blood. It was analyzed with the Roche Diagnostic kit on an Integra (800-Roche) biochemistry device. Tests used: Vertical Jump Test; 30 m. Sprint Test; Illinois Agility Test; Flexibility Test. Statistical analysis were performed by t-test, according to normality test in SPSS 10.0 package program.

Results The blood samples taken before and after the training were compared with creatine kinasevalues. It was seen that there was an increase and this increase returned to normal on the match day. In 30 meters sprint tests and Iliniois tests, significant reductions were found ($p<0.05$). While a significant difference was detected in the pre- and post-tests, pre-training and match day, no significant difference was found in CK values ($p>0.05$).

Conclusions Based on the results of this study, it can be recommended to reduce the intensity of the training to be done after the plyometric training due to the high CK value in the blood. It can be said that plyometric studies can play an important role in improving the performance of footballers.

Keywords: muscle damage, football, plyometrics, training

Introduction

The improvement of the football team performance and the personal performance of the footballers have caused an increase in the total distances run during a match each year. The rule that prevents the side shots from being played inside the penalty area has been changed. The players, who go back and forth between two goalposts at a distance of 60-70 m, had to increase their performance, physical and physiological strength by going back and forth between two goalposts at a distance of about 90m, at different speeds, together with the change of this rule. The success of the team and the continuity of the match of the footballers increased the physical and physiological load under these conditions, and thus the risks of serious injury increased. With the intense match traffic and the intensity of the national matches, football has started to be played faster and more paced with the updated game rules. That the players are free from injury, their performance is always at the highest level, playing matches with the same team skeleton and continuing the season have always been the first priority of the coaches. Having a football player profile that can maintain the existing capacity at the highest level during the match and has the best endurance characteristics has been the first priority of the coaches [1-3]. Athletes who use their physical strength best, who do not get tired easily, who can rest quickly and who can recover, are tried to be included in the transfer lists by paying astronomical prices, especially by European clubs with huge budgets [4-6]. In the analyzes made on the footballers playing in the national teams, it was found that they ran a distance of approximately 10-12 km during the match, this distance increased every year with the further development of their training models. And it was also found that footballers tried to do of approximately 10 difficult and combined movement out of 1200 independent movements in every 3-5 seconds. It has been revealed by the researches made by scientists that they try to run forward and backward by sprinting 30-40 m to the opponent and the ball, and perform more than 700 movements that require speed, agility and skill [7, 8]. Football matches are tougher, more aggressive and have higher intensity compared to previous years. The number of matches played by footballers today has also increased compared to the past. Therefore, in today's football, footballers need more strength and endurance. In the studies on football injuries, it is reported that while hamstring (back leg) injuries

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[9] constitute 7% of football player injuries, this rate has increased to 12-17% today [10]. In the studies conducted in the English leagues, it is estimated that the cost of injury in a season exceeds one hundred (100) million pounds. For this reason, various studies show that footballers reach an improved physical capacity with strength training, which also reduces the risk of injury [11].

Hamstring injury is the most common type of injury in football [12 -15]. There are many potential risk factors for hamstring injuries, such as age, athlete's position, previous hamstring injury, musculature, fatigue, flexibility and strength. Injuries in the hamstring group of muscles are usually seen in two joints as a result of sudden and excessive contraction of the muscles. These are hip flexion and knee extension [16]. Eniseler [11] reported that it is important to develop the hamstring muscle group, so that injuries that may occur can be prevented and that it will make an important contribution to football player performances during the match, and he hasalsoreported that pliomeric training is an indispensable part of football training. He stated that by improving hamstring strength with eccentric contraction, hamstring muscle injuries are reduced and the highest efficiency is achieved with plyometric training, especially in such football-specific exercises. For this reason, plyometric training is an indispensable element in transforming the strength gained into football-specific power.

Plyometric studies have an important place in many studies applied to develop the muscle groups used especially when performing high speed and power movements with and without the ball. It has been shown that plyometric studies especially improve physical performance (speed, quickness, agility, anaerobic capacity) [17]. Although plyometric exercises in various branches are used by many trainers and performance developers as a common working method used for speed, explosive power, explosive reaction and eccentric muscle control in dynamic movements, it is known that these exercises cause muscle damage and muscle injuries [18 - 20]. The first signs of damage immediately after exercise are decreased strength and loss of function. The damage to the muscle is more prominent after an unadapted exercise, depending on the intensity and volume of the exercise [21]. If the training is unusual or very intense, the muscles can be damaged and take time to return to normal. A suitable recovery is needed according to the intensity of the training. For these reasons the muscle damage experienced is called training-related muscle damage [22]. Creatine kinase (CK), the enzyme that determines muscle damage, increases in serum during muscle damage. An increase in the level of CK in the serum is an indicator of muscle tissue damage [23 - 25]. It is known that in muscle damage that occurs after training, the blood CK value increases depending on the race, gender, age and exercise type of the individual. The rate of clearance from blood values varies according to the lymph flow of the person and the severity of the damage. At the end of the 24 hour period following the exercise, the creatine kinase concentration, which reaches its highest value, starts to decrease at the end of 48 hours and returns to its pre-exercise level after 72 hours [26, 27]. Eryılmaz et. al. [28] found damage in CK and lactate dehydrogenase (LDH) levels in blood samples taken after 30 m repetitive sprint training. It can be said that this may be due to the fact that the fatigue level of the athletes is at the highest level when the training scope of the athletes is increased

In the light of the literature research, the purpose of this study is to determine whether the footballers carry the risk of injury after the plyometric training applied starting from the preparatory period in amateur footballers. The aim is to compare the blood samples taken before and after plyometric training with the creatine kinase values, to see if they carry the risk of injury and if there is a risk, to help investigate how much it affects the match day.

Material and Methods

Participants.

19 athletes (age 23.41 ± 3.2 years) who are both amateur footballers and students in the faculty of sports sciences without any injury or disease constitute the sample of the research (see table 1). Football players were given three predetermined plyometric training forms, the difficulty level of which was predetermined and repeated in each training. In this experiment, informed consent was obtained from all participants. All procedures were in accordance with the 2021 Declaration of Helsinki. This study was approved by Kahramanmaraş Sütçü İmam University Ethics Committee for research on human participants (2021/02).

Table 1. Anthropometric characteristics of the participants

Variables	Plyometric Group Mean±SD
Age (year)	23.41 ± 3.2
Height (cm)	169 ± 0.19
Weight (kg)	64.0,6± 7.12
BMI	21.02 ± 8.11

Research Design

In the 6th week of the competition period, just before and immediately after the training, blood samples were taken by the health personnel under hygienic conditions and transferred to a private hospital laboratory. CK activity was determined in sera obtained from centrifuged blood. It was analyzed with the Roche Diagnostic kit on an Integra (800-Roche) biochemistry device.

Vertical Jump Test

Before the jump, athletes try to reach the highest point on the previously marked wall with bare feet, body in an upright position and one arm stretched and the last contact point is determined. Without moving, the athlete just shrinks, tries to jump up with two feet and the end point touched is marked. The end point touched by jumping is recorded. The best of the three attempts is taken. Vertical jump test is one of the most used tests in measuring strength and explosiveness [29].

30 m. Sprint Test

The test battery developed to measure the speed performance of footballers includes players' passing a distance of 30 meters with the fastest speed by spending maximum effort. During the trials, the photocell was placed at meters 0 and 30meters. The athlete started 1 m behind the photocell. The athlete's values at the end of meters 30 were recorded. The best of the two trials was evaluated. Reliability coefficient was found as α = .74 for 30 m sprint [30].

Illinois Agility Test

The limits were determined with funnels placed on the corners of the area with a width of 5 meters and a length of 10 meters where the test would be performed and the athletes' departures and returns were directed with arrows drawn on the floor. The area where the test would be performed was divided in two longitudinal parts. Four funnels with a distance of 3.3 meters were placed on the mid line. The athletes started the test from one meter behind the photocell when they felt ready. Two trails were performed by taking rest and recovery into consideration, and the best result was evaluated [31].

Flexibility Test

The upper surface of the sit and reach box, which has a length of 35 cm, width of 45 cm, height of 32 cm with an upper surface length of 55 cm and width of 45 cm, is 15 cm further than the surface on which the feet rest. 0-50 cm measurement ruler is indicated with 5 cm parallel line intervals on the upper surface. After the athletes warm up, they sit with their bare feet soles under the 15 cm shorter part of the test table and they reach forward as far as possible with the hands in front of the body without bending the knees. The best of the two attempts is determined in cm [32].

Predetermined standard football training programs were applied to all athletes in the study 5-6 days a week during the preparation and competition period. Pre-training, post-training and matchday blood samples were taken at the sixth and sixth week of the preparation phase and competition period (see table 2).

Table2. Footballers plyometric work design and tests

Group / Number of footballers	Research Group (n=/19)
Number of Football Practices per Week	5 Day
The Beginning of Plyometric Trainings	Preparation Period III. week
Plyometric Training Preparation Period Number of Weekly Work	2 Day
Plyometric Training Competition Period Weekly Number of Work	1 Day
Plyometric Training Time / Rest Time (sec)	20min / 1:10sec
Performance Pre-Tests	Preparation period III. week
Performance Post –Tests	Preparation period VI. week
CK Pre-workout First test	Competition Period VI. week
Second test after CK Training	Competition Period VI. week
CK Final Test	Competition Period VI. week

The design of the Plyometric Training program was developed by the researcher.

12 plyometric movements, which are thought to improve agility, speed and power, were applied to the footballers within the standard football training program (see table 3).

Plyometric training Program

They completed the plyometric training program applied to footballers by performing sprint movements with a change of direction, varying between 2 and 6 meters, two days a week during the preparation period and once a week during the competition period (table 4).

Statistical Analyses

Data analysis was performed by the SPSS software version 22.0 program. Data were expressed as mean ± standard deviation (ss). The t test was used to determine the differences between groups. Variances were found to be homogeneous for all protocols. Significance level was interpreted according to $p<.05$, $p<0.1$ and $p<.001$.

Results

According to table 5 after the plyometric training, in the pre-test and post-test values of the footballers. In 30 meters sprint tests and Ilinoiis tests, significant reductions were found ($p<0,05$). Significant increases were found in vertical jump and flexibility values ($p<0,05$).

Pre, Pre-training, Post, Post-training

According to table 6 comparing the pre-test and post-test blood values of the plyometric training

Table 3. Plyometric movements applied to footballers

1st Plyometric Movement	One legged side over barrier (OLSB)
2 d Plyometric Movement	Ankle hops (AH)
3 d Plyometric Movement	Sid hope over barrier (SHB)
4 th Plyometric Movement	Lateral bounding (LB)
5 th Plyometric Movement	One leg bounding (OLB)
6 th Plyometric Movement	Standing long jump (SLJ)
7 th Plyometric Movement	Splitsqut Jumps(SJ)
8 th Plyometric Movement	LandingTecnique(LT)
9 th Plyometric Movement	TuckJums(TJ)
10th Plyometric Movement	Standing long jump lateral (SLJL)
11th Plyometric Movement	Standing long jump lateral Sprint (SLJLS)
12 Plyometric Movement	Standing long jump with barrier jump (SLJBJ)

OLSB = one legged side over barrier; AH = ankle hops ; SHB = sid hope over barrier; LB = lateral bounding; OLB = one leg bounding; SLJ = standing long jump; SJ = splitsqut jumps; LT= landing technique; TJ= tuck jumps; SLJL = standing long jump lateral; SLJLS = standing long jump lateral sprint; SLJBJ= standing long jump with barrier jump.

Table 4. Plyometric training program

Season	Weekday		Plyometric Exercises	Set	The number of repetitions	Between Set Rest.(s)	Training intensity
Preparation Period	3	Tuesd	1^{st} OLSB	2	3	1:6	% 60-70
			2^{d} AH	2	3	1:6	% 60-70
			3^{d} SHB	2	3	1:6	% 60-70
		Thurs	3^{d} SHB	2	3	1:6	% 60-70
			4^{th} LB	2	4	1:6	% 60-70
			6^{th} SLJ	3	4	1:7	% 80-90
	4	Tuesd	1^{st} OLSB	3	4	1:7	% 80-90
			3^{d} SHB	3	5	1:7	% 80-90
			5^{th} OLB	3	6	1:8	% 80-90/2-3m. sprint
		Thurs	7^{th} SJ	3	6	1:8	% 80-90
			8^{th} LT	3	6	1:8	% 80-90/2-3m sprint
			9^{th} TJ	3	6	1:8	% 100/ 2-3m sprint
Competition period	5	Wednes	10^{th} SLJL	3	6	1:10	
			11^{th} SLJLS	3	6	1:10	% 100/5-6m sprint
			12^{th} SLJBJ	3	6	1:10	
	6	Wednes	10^{th} SLJL	3	6	1:10	
			11^{th} SLJLS	3	6	1:10	% 100/5-6m sprint
			12^{th} SLJBJ	3	6	1:10	
	7	Wednes	9^{th} TJ	3	6	1:10	
			11 SLJLS	3	6	1:10	% 100/5-6m.sprint with change of direction
			12 SLJBJ	3	6	1:10	
	8	Wednes	10^{th} SLJL	3	6	1:10	
			11^{th} SLJLS	3	6	1:10	% 100/5-6 m. sprint with change of direction
			12^{th} SLJBJ	3	6	1:10	

“Sunday”.Tuesd = Tuesday; Thurs = Thursday; Wednes = Wednesday. *The Plyometric Training program was developed by the researcher assuming that the match days would be on

Table 5. Analysis results for physical performance “pre-test and post-test” values of footballers doing pilepliometric training.

Variable	Measure	X(n=19)	ss	t	p
30 m sprint	Pre	4,13	0,14	2,52	0,03**
	Post	4,11	0,08		
Vertical jump tests	Pre	2,70	0,12	1,72	0,00**
	Post	2,76	0,09		
İllinois agility	Pre	18,22	0,88	1,72	0,03**
	Post	16,99	0,72		
Flexibility	Pre	23,44	3,20	6,71	0,00**
	Post	26,57	3,66		

Pre; Pre- training, Post; Post-training

Table 6. Analysis results for “pre-test and post-test” values for variables of blood values of footballers participating in the study.

Variable	Measure	X (n=19)	ss	t	p
CK before and after training	Pre	161,63	60,74	-3,65	0,002**
	Post	228,21	62,37		
CK pre-training and matchday, before the match	Pre	161,63	60,74	0,34	0,732
	Post	156,10	29,10		

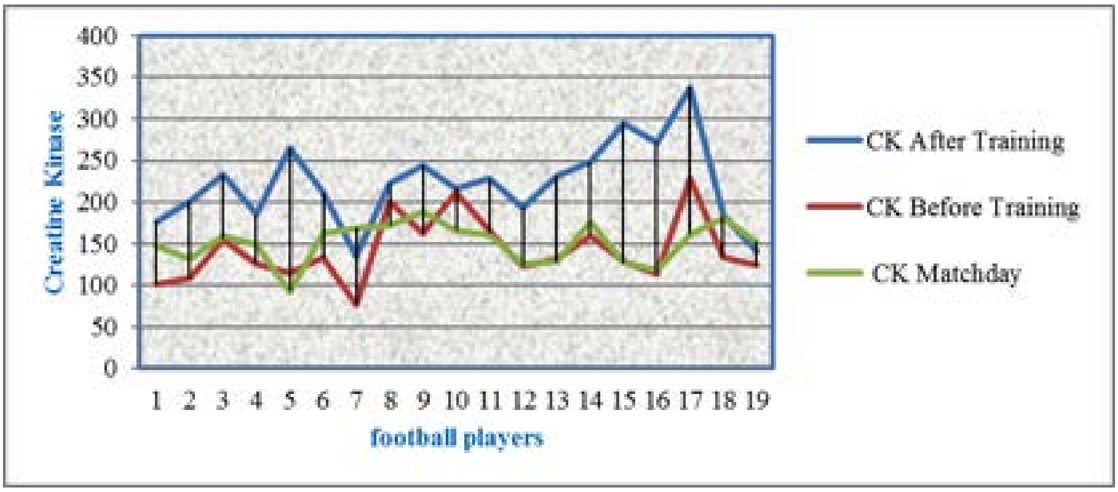

Figure1. Creatine kinase (CK) values of the players before training, after training and match day

program data, before and after training values. While a significant difference was detected in the pre- and post-tests, pre-training and match day, no significant difference was found in CK values (p>0.05).

When figure1 is examined, when the blood samples taken and the CK values before and after the training were compared, an increase was observed, and it was seen that this increase returned to the normal level on the match day.

Discussion

In this study it was observed that there was a significant increase in CK values in pre-test and post-test results in blood tests taken from footballers aged 19-28 before and after training. However, it was determined that there was no significant difference in the pre-training and pre-match CK values of the athletes (see table 6 and see figure 1). According to the analysis results; It was seen that plyometric trainings made a significant contribution to the performances of football (see table 5). Based on these results, it can be said that plyometric studies (see Table 4) will not cause injuries on the match day, as pre-match CK values return to normal.

In addition, it is frequently reported in the literature that plyometric exercises significantly improve the performance of athletes.

Eniseler [11] and Baechle [33] defined the aim of plyometric training as reaching maximum power and improving speed ability with the strength gained during activities performed at a certain speed close to the maximum. At the same time, plyometric exercises are very important for the development of sportive performance in footballers who use speed, agility and strength together. They state that there is muscle strength in exercises without the ball such as jumping, sprinting, agility, interventions involving intense contact, and all exercises with the ball.

Lin et al [34] investigated the effects of plyometric training and creatine monohydrate supplementation on anaerobic capacity and muscle damage in their study on 26 male athletes. As a result, they found that plyometric exercises significantly improved the development of the anaerobic capacity of the athletes, as well as their characteristics such as speed and agility.

The peak time of creatine kinase, which rises after exercise, varies depending on the intensity, type and duration of exercise. In other studies, different results were obtained regarding the peak time. It has been revealed after the researches that the CK value reaches its highest level 2 or 4 days after the exercise [22].

Kaplan [35] evaluated muscle enzymes in terms of muscle damage caused by Nordic Hamstring Exercise and Slide Board Hamstring Curl Exercise, which are eccentric exercises used in sports branches in his study on footballers. It was reported that muscle enzyme values continued to increase 3, 24 and 48 hours after exercise.

Khan et al. [36] in his study in which he examined the sprint values of footballers and the muscle damage due to them, stated that the CK value in the blood after the tests may last for 24-48 or even 72 hours. This result of the research shows parallelism with our research results.

Conclusions

Based on the results of this study, it can be recommended to reduce the intensity of the training to be done after the plyometric training due to the high CK value in the blood.

It can be said that plyometric studies can play an important role in improving the performance of footballers.

In the light of this information, the CK value in the blood may increase after a plyometric training, which may cause injury. For this reason, it is necessary to pay attention to the load that may cause injury while planning the studies after the competition period plyometric training.

It can be said that the inclusion of plyometric training programs in addition to the existing training programs of footballers can contribute to the development of physical performances such as speed, agility and changing direction at high speed, which they encounter most during the match.

Suggestions

Coaches will significantly contribute to footballers development if they include plyometric training to the current training period (preparation, competition period or transition period) by taking the football player's age, the scope of the training into consideration. It can be said that the plyometric training programs applied to this group can also be applied in teams of lower age groups by changing the number of repetitions and rest periods according to the difficulty levels and age categories. The subject of this study can also be applied in amateur footballers by considering the differences between positions. The effects of plyometric training in different branches and in different age categories, the muscle damage of players, and physical and physiological parameters can also be examined.

In different studies, changing muscle enzyme levels can be compared by changing gender or age groups. As another suggestion, this study can be applied to the sample by adding more detailed and detailed biochemical tests.

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Conflict of interest

The author declare no conflict of interest.

References

1. Armstrong, R, Greig M. The Functional Movement Screen and modified Star Excursion Balance Test as predictors of T-test agility performance in university rugby union and netball players. *Physical Therapy in Sport*; 2018; 31: 15–21. https://doi.org/10.1016/j.ptsp.2018.01.003
2. Zemková E. Differential contribution of reaction time and movement velocity to the agility performance reflects sport-specific demands. *Human Movement,* 2016; 17(2): 94–101. https://doi.org/10.1515/humo-2016-0013
3. Greig M, Naylor J. The efficacy of angle-matched isokinetic knee flexor and extensor strength parameters in predicting agility test performance. *International Journal of Sports Physical Therapy,* 2017; 12,(5): 728–736. https://doi.org/10.26603/ijspt20170728
4. David D, Rodney K, Jonny D, Matthew G, Simon M, Amy D. A Step towards a Field Based Agility Test in Team Sports. *Int J Sports Exerc Med*, 2017;3. https://doi.org/10.23937/2469-5718/1510079
5. Bradshaw RJ, Young WB, Russell A, Peter B. Comparison of offensive agility techniques in Australian Rules football. *Journal of Science and Medicine in Sport,* 2011; 14(1): 65–69. https://doi.org/10,1016/j.jsams.2010.06.002
6. Paul DJ, Gabbett T.J, Nassis G.P. Agility in team sports: testing, training and factors affecting performance. *Sports Medicine,* 2016. 46(3): 421–442. https://doi.org/10.1007/s40279-015-0428-2
7. Iaia FM, Rampinini E, Bangsbo J. High-intensity training in football.*Int Journal Sports Physiol Perform*. 2009 4: 291–306.https://doi:10.1123/ijspp.4.3.291
8. Dellal A, Varlıette C, Owen A, Chırıco EN, Adam H. Small-sıded games versus Interval training in amateur soccer players, effects on the aerobic capacity and the ability to perform intermittent exercises withc hanges of direction. *Journal Strength CondRes*, 2012; 26(10):2712–2720. https://doi.org/10.1519/JSC.0b013e31824294c4
9. Srámek P, Simecková M, Janský L. Human physiological responses to immersion into water of different temperatures. *Eur Journal Application Physiol*.2000;81(5):436–42. https://doi.org/10.1007/s004210050065
10. Bailey DM, Erith SJ. Griffin PJ. Influence of cold-water immersion on indices of muscle damage following prolonged intermittent shuttle running. *Journal of Sports Sciences,* 2007; 25(11): 1163–1170. https://doi.org/10.1080/02640410600982659
11. Eniseler N. *Football in the Light of Science*. İzmir: United printing; 2010.
12. Ekstrand J, Hagglund M, Walde M. Epidemiology of muscleinjuriesin Professional soccer. *Am Journal of Sports Medicine,* 2011;39(6):1226–1232. https://doi.org/10.1177/0363546510395879
13. Timmins RG, Bourne MN, Hickey JT, Maniar N, Tofari PJ, Williams MD, et al. Effect of Prior Injury on Changes to Biceps Femoris Architecture across an Australian Football League Season. *Medicine & Science in Sports & Exercise*, 2017;49:2102–9. https://doi.org/10.1249/MSS.0000000000001333
14. Presland JD, Timmins RG, Bourne MN, Williams MD, Opar DA. The effect of Nordic hamstring exercise training volume on biceps femoris long head architectural adaptation. *Scand J Med Sci Sports*, 2018;28:1775–83. https://doi.org/10.1111/sms.13085
15. Hickey JT, Hickey PF, Maniar N, Timmins RG, Williams MD, Pitcher CA, et al. A Novel Apparatus to Measure Knee Flexor Strength During Various Hamstring Exercises: A Reliability and Retrospective Injury Study.*J Orthop Sports Phys Ther*,2018;48:72–80. https://doi.org/10.2519/jospt.2018.7634
16. Brucker PU, Imhoff AB. Functional assessment after acute and chronic complete ruptures of the proximal hamstring tendons. *Knee Surg Sports Traumatol Arthrosc*, 2005;13:411–8. https://doi.org/10.1007/s00167-004-0563-z
17. Ciğerci AE.*The effects of aquatic and land pliometric trainings with additional load on some physical and physiological features of 15-17 age group basketball players* [PhD Thesis]. Ankara: Gazi University; 2017.
18. Coetzee B. An overview of plyometrics as an exercisetechnique. *South African Journalfor Research in Sport Physical Education and Recreation,* 2007;29(1):61–82. https://doi.org/10.4314/sajrs.v29i1.25956
19. Twist C, Roger GE.Theeffects of exercise-induced muscle damage on maximal intensity intermittent exercise performance.*EuropeanJournal of Applied Physiology,* 2005; 94: 652–658. https://doi.org/10.1007/s00421-005-1357-9
20. Tofas T, Jamurtas AZ, Fatouros I, Nikolaidis MG, Koutedakis Y, Sinouris EA. Plyometric exercise increases serum indices of muscledamage and collagen breakdown. *The Journal of Strengt hand Conditioning Research,* 2008; 22(2): 490–496. https://doi.org/10.1519/JSC.0b013e31816605a0
21. Smith LL, Mıles MP. Exercise ınduced muscle ınjury and ınflamation. In: Garrett JR, Kırkendall DT.(ed). *Exercise and SportScience*. Philadelphia: Lippincott Williams And Wilkins; 2000. P. 401–411.
22. Kosova S, Beyhan R, Koca Kosova M. The effect of 8-week plyometric training on jump height, agility, speed and asymmetry. *Pedagogy of Physical Culture and Sports*, 2022;26(1):13–18. https://doi.org/10.15561/26649837.2022.0102
23. Schwane JA, Watrous BG, Johnson SR, Armstrong RB. Is Lactic Acid Related to Delayed-Onset Muscle Soreness? *The Physician and Sportsmedicine*, 1983;11:124–31. https://doi.org/10.1080/00913847.1983.11708485
24. Clarkson PM, Byrnes W, Mccormick K, Turcotte LP, White JS. Musclesoreness and serum creatine kinase activity following isometric, eccentric, and concentric exercise. *Int Journal of Sports Medicine,* 1986;7(3):152–51. https://doi.org/10.1055/s-2008-1025753
25. Vıncent HK, Vıncent KR. Theeffect of traning status on the serum cretine kinese response, soreness and muscle fonction fallowing resistance exercise.

Journal Sports Medicine, 1997; 18(6):431–437. https://doi.org/10.1055/s-2007-972660
26. Totsuka M, Nakaji S, Suzuki K, Sugawara K, Sato K. Breakpoint of serum creatine kinase after endurance exercise. *Journal Applied Physiol.* 2001; 93:1280–1286. https://doi.org/10.1152/japplphysiol.01270.2001
27. Schneıder CM, Dennehy CA, Rode AJ, Hayvard JR. Effects of physial activity on creaitiane phopsokinase and the ısoenzyme creatine kinase–MB. *Annals of Emergency Medicine.* 1995;25(4): 520–524. https://doi.org/10.1016/S0196-0644(95)70270-9
28. Eryılmaz SK, Aslankeser Z, Ozdemir C, Ozgunen K, Kurdak S. The effect of 30-m repeated sprint exercise on muscle damage indicators, serum insulin-like growth factor-ı and cortisol. *Biomedical Human Kinetics*, 2019; 11(1): 151–157. https://doi.org/10.2478/bhk-2019-0021
29. Miller T. *NSCA'sguide to tests and assessments*. Champaign IL: Human Kinetic; 2012.
30. Erol E. ExperimentalinVestigation of the effect of rapid strength training on the performance of 16-18 age group young basketball players [MSc Thesis]. Ankara: Gazi University; 1992.
31. Roozen M. Illinois agility test. *NSCA's Performance Training Journal,* 2004*;* 3(5): 5–6.
32. Tamer K. *Measurement and Evaluation of Physical-Physiological Performance in Sports*. 2nd Edition. Ankara: Bağırgan Publishing House; 2000.
33. Baechle TR. *The essentials ofstrength trainingand conditioning*. Human Kinetics; 1994.
34. Lin YY, Lin JS, Lin YF, Fang CL, Lin HC. Effects of plyometric training and creatine monohydrate supplementation on anaerobic capacity and muscle damage. *Gazzetta Medica Italiana Archivio per le Scienze Mediche*, 2012;171(3):313–22.
35. Kaplan İM. Muscle damage responses of two different eccentric hamstring exercises (Master'sthesis, University [MSc Thesis]. Denizli: *Pamukkale University Institute of Health Sciences*; 2019.
36. Khan MA, Moiz JA, Raza S, Verma SMY, Anwer S, Alghadir A. Physical and balance performance following exercise induced muscle damage in male soccer players. *Journal of Physical Therapy Science,* 2016; 28(10): 2942–2949. https://doi.org/10.1589/jpts.28.2942

Information about the author:

Tayfun Şirin; https://orcid.org/0000-0001-6305-0097; tayfunksu@gmail.com; Department of Coaching Education, Faculty of Sport Science, KahramanmarasSutcu Imam Universty; Kahramanmaraş, Turkey.

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ORIGINAL ARTICLE

Comparison of hamstring quadriceps strength ratios in different combat sports branches

Ali Tatlici[1ABCDE], Berkay Löklüoğlu[2ADE]

[1]*Faculty of Sports Sciences, Selcuk University, Konya, Turkey*
[2] *High school of Physical Education and Sports, Hatay Mustafa Kemal University, Hatay, Turkey*

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim	The hamstring and quadriceps muscles can have strength differences because of the sportive activities. It is known that sportive hamstring quadriceps strength imbalance can cause decreasing sportive performance and injuries. Also, each sports branch can have a specific effect on the hamstring quadriceps strength ratio. Therefore, the aim of this study was to examine the effects of different combat sports branches on the hamstring quadriceps ratio.
Material and Methods	Wrestlers (N=10), boxers (N=10), wushu athletes (N=10) voluntarily participated in the study (also university students). Subjects were administered standard warm-up and then a strength measurement test was performed. Subjects performed knee extensor (quadriceps) and flexor (hamstring) isokinetic strength test (concentrically) with his dominant leg at 60° angular velocity with by Cybex device (Cybex NORM®. Humac. CA. USA). Peak and average strength were recorded automatically by the device. The SPSS package program was used in the analysis of the data. The isokinetic strength measurements of three groups were analyzed with one-way ANOVA.
Results	There were no significant differences between groups' peak isokinetic strength ratio (wrestlers 0.58±0.09 boxers 0.56±0.07 and wushu athletes 0.57±0.12). Also, the average isokinetic strength ratio was not significantly different (wrestlers 0.56±0.08. boxers 0.60±0.08 and wushu athletes 0.53±0.11).
Conclusions	According to the results, it can be said that combat sports athletes' hamstring quadriceps ratio can be affected by their sports branches, also by characteristics and training levels.

Keywords: imbalance, hamstring, quadriceps, ratio.

Introduction

Muscle strength is one of the most important components of sports for both the prevention of injuries and high performance. There are several ways to assess muscle strength, balance and joint stabilization. The most useful method for determining muscle balance and strength between dominant/non-dominant and agonist/antagonist is isokinetic dynamometers [1]. For years, isokinetic dynamometers have been used to determine muscle balance and strength, as well as for muscle development and rehabilitation [2]. In addition, determining the isokinetic strength profiles of the athletes in different branches has great importance in terms of providing the continuity of the requirements of the branch and the high-level performance of the athletes [3].

Muscle fatigue is a common problem in athletes. For this reason, it is necessary to evaluate muscle fatigue and its related results. Another important element in exercise and competition is knee joint stabilization. Joint stabilization consists of static and dynamic stabilization. Thanks to the hamstrings and quadriceps, dynamic stabilization is provided in the knee joint [1]. To assess the balance of strength between opposing muscle groups, the strength ratios of these muscle groups are measured. Studies on the hamstring-quadriceps strength ratio can provide accurate results about muscle balance and dynamic stabilization in the knee joint.

To make accurate assessments about muscle balance and dynamic stabilization in the knee joint, it is necessary to determine the H/Q (hamstring/quadriceps) strength ratios. The H/Q ratio is calculated by the ratio of the maximum knee flexor (hamstring) and maximum knee extensor (quadriceps) peak torques at the same angular velocity and concentric contraction. As an example, the functional H/Q ratio for knee extension is calculated by expressing the maximum eccentric hamstring moment relative to the maximum concentric quadriceps moment achieved at a given angular velocity [4]. This ratio is also known as a convenient parameter that shows trends towards injuries [5-8]. In addition, due to the importance of flexor-extensor muscle strength balance, the H/Q ratio is used for rehabilitation in case of knee injury [2, 9].

Except for acute trauma, athletes' injuries mostly occur due to strength imbalance. Because the amount of load on the musculoskeletal system is much higher in sports branches involving high-

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intensity activities compared to endurance sports, the risk of injury increases. Therefore, special attention should be paid to the strength balance of muscle groups when planning training in sports branches where high-intensity activities such as combat sports are dominant [10].

As with many sports branches, combat sports have specific effects in terms of hamstring quadriceps strength ratios. These effects may differ from branch to branch. Therefore, this study aimed to examine the effects of different combat sports branches on the hamstring quadriceps ratio.

Materials and Methods

Participants

Total 30 athletes; wrestlers (n=10 age 20.40±1.57 year, height 178.30±6.75 cm and body weight 77.20±8.71kg), boxers (n=10, age 21.40±2.67 year, height 173.20±7.70 cm and body weight 69.30±9.58 kg), wushu athletes (n=10, age 21.70±2.21year, height 178.00±5.14 cm and body weight 78.50±9.62 kg) voluntarily participated in the study (also university students, at least 5 years experience).

Participants were informed about the risks of the study. All participants provided written informed consent. The study was approved by the local ethics committee (Protocol number 74, 19.10.2020, Ethics Committee of Selcuk University, Faculty of Sports Science, Konya, Turkey).

Research Desing

5 min standardized warm-up protocol was performed on a cycle ergometer at a rate of 60–70 rpm before isokinetic strength testing. After warming up, measurements of the knee isokinetic flexor (hamstring) and extensor (quadriceps) muscle strengths of the participants' dominant legs were taken with the concentric contraction protocol. The isokinetic strength measurements were taken using a cybex device (Cybex NORM®. Humac. CA. USA) at 60 ° sec^{-1} angular velocity. Peak and average isokinetic strength measurements were recorded automatically by the device.

Isokinetic Strength Measurement

The isokinetic strength measurements of the knee were performed by an isokinetic dynamometer (Cybex NORM®, Humac, CA, USA) in the kinatropometry laboratory of Selcuk University. Participants were seated in the correct position in the test seat. The participants' holders and the middle sections of the thighs were stabilized to the seat by the tapes. In addition, they were allowed to brace for support by holding the handles on the right and left sides of the seat during the test. The participants were instructed to complete a ROM from 90° to 10°. The point of the beginning was 90° of flexion, then moving into extension.

Each participant was given a familiarization at 60° sec^{-1} for five repetitions [11]. When the familiarization was done, each participant had a 2-min rest. After the rest period, each participant was asked to perform five repetitions as hard and fast as possible he could at a speed of 60° sec^{-1}. Participants were verbally encouraged. The isokinetic strength data were automatically recorded by the device as peak strength in newton meters and average strength in watts.

Statistical Analysis

The data were presented as mean and standard deviation. The Shapiro-Wilk test is used to check a data set for normality to make parametric tests applicable. Skewness and kurtosis values were checked for datasets that were not normally distributed, and those within ±2 were accepted to be normally distributed. One-way ANOVA used for data analysis in comparing multiple parameters. All statistical tests were performed using the software package SPSS version 24.0 (SPSS Inc., Chicago, IL, USA). An alpha value of <0.05 was considered to be statistically significant.

Results

Table 1 shows that there is no statistical difference between the groups in terms of age, height and body weight.

When the isokinetic strength outputs were examined, it was found that the isokinetic strength parameters of groups were not statistically different (see Table 2).

In table 3. when the relative isokinetic strength outputs were examined, it was found that there were no statistically difference between groups relative isokinetic strength parameters.

The peak strength ratios and the average strength ratios of the groups did not differ statistically (see Table 4).

Table 1. Comparison of demographic characteristics of groups.

Variables	Box	Wrestling	Wushu	P
	Mean±SD	Mean±SD	Mean±SD	
Age (year)	21.40±2.67	20.40±1.57	21.70±2.21	0.39
Height (cm)	173.20±7.70	178.30±6.75	178.00±5.14	0.17
Body Weight (kg)	69.30±9.58	77.20±8.71	78.50±9.62	0.64

*Statistically significant differences (P< 0.05).

Table 2. Comparison of isokinetic strength of groups

Variables	Groups	Mean	Std. Deviation	95% Confidence Interval		F	P
				Lower	Upper		
Peak	Box	221.50	48.87	186.54	256.46		
Extension	Wrestling	241.00	21.79	225.41	256.59	1.793	0.18
(Torque)	Wushu	250.60	28.56	230.17	271.03		
Peak	Box	124.90	28.16	104.76	145.04		
Flexion	Wrestling	141.10	31.41	118.63	163.57	1.059	0.36
(Torque)	Wushu	142.40	30.22	120.78	164.02		
Average	Box	155.30	30.32	133.60	177.00		
Extension	Wrestling	168.30	18.84	154.82	181.78	2.230	0.12
(Watt)	Wushu	175.80	13.13	166.41	185.19		
Average	Box	93.10	20.60	78.36	107.84		
Flexion	Wrestling	94.30	12.89	85.08	103.52	0.011	0.98
(Watt)	Wushu	93.70	20.30	79.18	108.22		

*Statistically significant differences (P<0.05).

Table 3. Comparison of relative isokinetic strength of groups

Variables	Groups	Mean	Std. Deviation	95% Confidence Interval		F	P
				Lower	Upper		
Peak	Box	3.18	.49	2.83	3.54		
Extension	Wrestling	3.14	.29	2.92	3.35	0.130	0.87
(Torque)	Wushu	3.25	.66	2.78	3.72		
Peak	Box	1.79	.24	.07	1.61		
Flexion	Wrestling	1.82	.33	.10	1.58	0.40	0.96
(Torque)	Wushu	1.83	.47	.14	1.50		
Average	Box	2.24	.32	2.01	2.47		
Extension	Wrestling	2.18	.19	2.04	2.32	0.198	0.82
(Watt)	Wushu	2.27	.36	2.01	2.53		
Average	Box	1.33	.18	1.20	1.47		
Flexion	Wrestling	1.22	.15	1.11	1.34	0.942	0.40
(Watt)	Wushu	1.20	.30	.99	1.42		

*Statistically significant differences (P<0.05).

Table 4. Comparison of peak and average strength ratios of groups

Variables	Groups	Mean	Std. Deviation	95% Confidence Interval		F	P
				Lower	Upper		
Peak	Box	.56	.07	.51	.61		
Rate	Wrestling	.58	.09	.51	.65	.057	0.94
(Torque)	Wushu	.57	.12	.48	.66		
Average	Box	.60	.08	.54	.66		
Rate	Wrestling	.56	.08	.50	.62	1.096	0.34
(Watt)	Wushu	.53	.11	.45	.62		

*Statistically significant differences (P<0.05).

Discussion

Muscle strength is one of the most important indicators of success in sports performance and prevention of injury. Some methods are used to evaluate muscle strength. One of them is isokinetic strength assessment [3,9]. The H/Q ratio is frequently evaluated to examine functional ability, knee joint stability, and muscle balance between the hamstrings and quadriceps at various angular velocities. It is also a widely used variable to evaluate function in both athletes and patients with various knee injuries and pathologies [12]. The H/Q ratio shows different specific effects from branch to branch. Therefore, it was examined the isokinetic strength values of athletes participating in combat sports branches as well as effects of different combat sports branches on the hamstring quadriceps ratio in this study. The results demonstrate that hamstring quadriceps ratio of combat sports athletes can be affected by their sports branches, also by characteristics and training levels.

It is known that it is important to evaluate the isokinetic knee strength values and H/Q ratios of athletes in many sports branches. In the literature, there are many studies comparing isokinetic knee strength values and the H/Q strength ratios of athletes in different sports branches. Some of these were performed with the dominant leg, while others were performed with both legs. In addition, the measurements were performed at different angular velocities. In the study of Andrade et al. [13] on soccer players, handball players and judo players, peak extension torque values at 60°·s-1 angular velocity were found to be higher in judokas, while peak flexion torque values were found to be similar. Magalhaes et al. [3] also reported that the peak extension torque values higher in soccer players than volleyball players, while the peak flexion torque values were similar. Cheung et al. [12] stated that the peak flexion torque values in soccer players were statistically higher than in volleyball players and basketball players, but the peak extension torque values were similar. In contrast, no statistically significant differences were found between sports branches in terms of isokinetic strength values at 60°·s-1 angular velocity in our study. Maly et al. [14] indicated that no statistically significant differences were found between soccer and floorball players in terms of isokinetic strength values. These results are similar to the our study. The finding of no differences in the isokinetic strength values in different sports may be associated with training adaptations and levels.

There are limited studies comparing the H/Q strength ratios of combat sports branches. However, when we examine the branches one by one, Tatlici et al. [15] reported that while H/Q strength ratios were 0.58 in the dominant leg before 8- week wrestling-specific training, it decreased to 0.52 after wrestling-specific training. Zhou et al. [16] on the other hand, stated that the strength ratio of boxers was 0.61 in the results of their study. Jung et al. [17] stated that the H/Q strength ratio of taekwondo athletes was 62.8 in their right legs and 59.4 in their left legs.

Andrade et al, [13] reported that the H/Q ratios of handball players and soccer players at an angular velocity of 60°·s-1 were similar, while the ratios of judokas were lower than other two sports branches. Magalhaes et al. [3] also reported that the H/Q ratios of soccer players were statistically higher than volleyball players. Cheung et al. (2012) stated that the H:Q ratio was statistically higher in soccer players at an angular velocity of 60°·s-1 than in volleyball and basketball players. In addition, Maly et al. [14] stated that soccer players have higher H/Q ratio values than floorball players at an angular velocity of 60°·s-1. These findings can be explained by the enhanced knee flexors specific load adaptation required by soccer. In contrast, Rosene et al. [9] reported that no statistically significant differences were found between soccer, volleyball and softball players in terms of H/Q ratio values. Similarly, Zakas et al. [18] stated that there were no statistical differences in terms of H/Q ratios between soccer players and basketball players playing in different leagues. In our study, no statistical differences were found between the H/Q strength ratios of athletes at an angular velocity of 60°·s-1 in different combat sports such as boxing, wrestling and wushu. Thus, it can be said that various combat sports have specific effects in terms of H/Q strength ratio.

Conclusions

According to the results, there were no significant differences between groups in terms of isokinetic strength parameters including peak and average values. Also, peak and average isokinetic strength ratios of groups did not differ statistically. Therefore, it can be said that combat sports athletes' hamstring quadriceps ratio can be affected by their sports branches, also by characteristics and training levels.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Olyaei G, Hadian M, Talebian S, Bagheri H, Malmir K, Olyaei M. The effect of muscle fatigue on knee flexor to extensor torque ratios and knee dynamic stability. *Arabian Journal for Science and Engineering*, 2006; 31: 121.
2. Alangari AS, Al-Hazzaa HM. Normal isometric and isokinetic peak torques of hamstring and quadriceps muscles in young adult Saudi males. *Neurosciences Journal*, 2004; 9: 165–170.
3. Magalhaes J, Ascensao A, Soares J. Concentric quadriceps and hamstrings isokinetic strength in volleyball and soccer players. *Journal of Sports Medicine and Physical Fitness*, 2004; 44: 119–125.
4. Aagaard P, Simonsen EB, Magnusson SP, Larsson B, Dyhre-Poulsen P. A new concept for isokinetic hamstring: quadriceps muscle strength ratio. *The American Journal of Sports Medicine*, 1998; 26: 231–237. https://doi.org/10.1177/03635465980260021201
5. Tsang KK, DiPasquale AA. Improving the Q: H strength ratio in women using plyometric exercises. *The Journal of Strength & Conditioning Research*, 2011; 25: 2740– 2745. https://doi.org/10.1519/JSC.0b013e31820d9e95
6. Watson MD, Collins BK, Davies GJ, Riemann BL. The Influence of Hip Flexion and Isokinetic Velocity on Hamstrings-Quadriceps Strength Ratios in Healthy Females. *Research Quarterly for Exercise and Sport*, 2021:1–7. https://doi.org/10.1080/02701367.2021.1908508
7. Li R, Maffulli N, Hsu YC, Chan KM. Isokinetic strength of the quadriceps and hamstrings and functional ability of anterior cruciate deficient knees in recreational athletes. *British Journal of Sports Medicine*, 1996; 30: 161–164. https://doi.org/10.1136/bjsm.30.2.161
8. Lee JW, Mok K-M, Chan HC, Yung PS, Chan K-M. Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. *Journal of Science and Medicine in Sport*, 2018; 21: 789–793. https://doi.org/10.1016/j.jsams.2017.11.017
9. Rosene JM, Fogarty TD, Mahaffey BL. Isokinetic hamstrings: quadriceps ratios in intercollegiate athletes. *Journal of Athletic Training,* 2001; 36: 378.
10. Özkan A, Kinişler A. Sporcularda bacak hacmi, kütlesi, hamstring/quadriceps oranı ile anaerobik performans ve izokinetik bacak kuvveti arasındaki ilişki [Relationships of leg volume, leg mass, anaerobicperformance and isokinetic strength in americanfootball players]. *Spor Bilimleri Dergisi*. 2010; 21: 90–102. (In Turkish). https://doi.org/10.1501/Sporm_0000000173
11. Van Cingel R, Kleinrensink GJ, Mulder P, de Bie R, Kuipers H. Isokinetic strength values, conventional ratio and dynamic control ratio of shoulder rotator muscles in elite badminton players. *Isokinetics and Exercise Science*, 2007; 15: 287–293. https://doi.org/10.3233/IES-2007-0285
12. Cheung R, Smith A, Wong D. H:Q Ratios and Bilateral Leg Strength in College Field and Court Sports Players. *Journal of Human Kinetics*, 2012;33:63–71. https://doi.org/10.2478/v10078-012-0045-1
13. Andrade MDS, De Lira CAB, Koffes FDC, Mascarin NC, Benedito-Silva AA, Da Silva AC. Isokinetic hamstrings-to-quadriceps peak torque ratio: The influence of sport modality, gender, and angular velocity. *Journal of Sports Sciences*, 2012; 30: 547–553. https://doi.org/10.1080/02640414.2011.644249
14. Maly T, Mala L, Bujnovsky D, Hank M, Zahalka F. Morphological and isokinetic strength differences: bilateral and ipsilateral variation by different sport activity. *Open Medicine*, 2019; 14: 207–216. https://doi.org/10.1515/med-2019-0014
15. Tatlici A, Lima Y, Çiftçi B, Aktas S, Badak T. The effect of 8-weeks wrestling training on unilateral muscle imbalances. *Physical Education of Students*, 2021; 25: 205–205-211. https://doi.org/10.15561/20755279.2021.0401
16. Zhou Z, Chen X, Chen C, Yi W, Wang D. Assessment of Isokinetic Knee and Shoulder Strength in Elite Youth Boxers: Correlation with Punch Impact Force. In Review; 2021. https://doi.org/10.21203/rs.3.rs-1064025/v1
17. Jung HC, Lee S, Seo MW, Song JK. Isokinetic assessment of agonist and antagonist strength ratios in collegiate taekwondo athletes: A preliminary study. *Sport Sciences for Health,* 2017; 13: 175–181. https://doi.org/10.1007/s11332-016-0337-2
18. Zakas A, Mandroukas K, Vamvakoudis E, Christoulas K, Aggelopoulou N. Peak torque of quadriceps and hamstring muscles in basketball and soccer players of different divisions. *The Journal of Sports Medicine and Physical Fitness*. 1995; 35: 199–205.

Information about the authors:

Ali Tatlici; Phd; http://orcid.org/0000-0001-6346-0010; alitatlici@selcuk.edu.tr; Faculty of Sports Science, Selçuk University; Konya, 42130, Turkey.

Berkay Löklüoğlu; (Corresponding Author); Res. Asst; https://orcid.org/0000-0003-2177-1624; berkaylokluoglu@mku.edu.tr; High School of Physical Education and Sports, Hatay Mustafa Kemal University, Hatay, Turkey

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ORIGINAL ARTICLE

Improving university students' coordinating skills in physical education lessons with basketball focus

Cristina I. Nae[ABCDE], Cristiana L. Pop[AD]

Bucharest University of Economic Studies, Romania

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection.

Abstract

Background and Study Aim The purpose of the study was to examine the effectiveness of a 14-week intervention in improving coordination skills among female university students. The intervention consisted in physical education lessons with basketball focus, the final practical outcome being to practice a coherent and satisfying game for the players.

Material and Methods The research was carried out on a group of 15 female university students aged 19-20, in the second semester of the academic year 2018-2019, lasted 14 weeks, with a frequency of 1 lesson per week. The applied tests were dynamic balance, body coordination, hands coordination, basketball spot shooting, wall passes. Measurements were performed before intervention as a baseline and after it to record the effect size. The manipulated variable was a physical exercises program designed in purpose to produce an effect on the dependent variable: coordination skills improvement. The significant mean difference and the effect size was statistically demonstrated with student t-test $p < 0.005$.

Results From the statistical data obtained, we found that the results of 'before and after' tests differ significantly. For all the parameters under discussion the effect magnitude was large and mostly very large, also the research hypothesis was accepted.

Conclusions Applying the designed program has led to a substantial improvement of coordinating skills and has positively influenced the effectiveness of the basketball technique learning process.

Keywords: coordination skills, basketball, female students, test battery.

Introduction

Coordination is a complex, multidisciplinary concept and therefore its definition varies depending on the field of movement science approached. Furthermore, there are different points of view within the same discipline. In biomechanics, for example coordination is viewed as a synergic action of elements aiming to achieve a common task, or an interrelation of different elements not necessarily acting toward a common goal [1].

Coordinated movements represent a distinct category of instrumental movements, which give the subject the opportunity to economize effort, motor action, in predictable (stereotypical) and unpredictable situations [2]. Coordination skills underpin all motor skills, with a particular role in all kinds of situations that require athletes' rational and quick action [3].

In Physical Education, coordination skills are an important basis for correct learning and practice of high-level motor skills and leads to the fast adjustment of the subject in different work conditions specific to different sports, basketball in our case [4].

The term 'coordination skills' has been established in the 1980s [5-9] but for a long period of time, this concept has been used alongside the terms: dexterity or a complex different skill combination.

Dexterity is defined as a complex form of expressing performance capacity [10] through the quick learning of new movements and fast adjustment to various situations, according to the specifics of each sport.

Because dexterity is a complex motor skill in its structure Colibaba & Bota [11] included:

- The precision of motor movements or mastery/ controlled movement;
- Fine mental guidance of the muscular chains: agonist, antagonist, synergist and fixator muscle;
- Kinesthetic sense;
- Ball movement and awareness;
- Ability to approximate distances;
- Ability to mobilize mentally;
- Mental factors capable to influence the sportsman's motor behavior positively or negatively.

Coordination is defined as a complex capacity correlated with speed, strength, endurance, and mobility. From a physiological point of view, coordination is determined by genetic and environmental factors [12]. Coordination abilities depend highly on the efficient functioning of the central nervous system.

The level of coordination represents the ability

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to execute movements having different degrees of difficulty, quickness, with great accuracy and high efficiency in accordance with the specific objectives of the training [13]. Of all the motor abilities, muscle strength affects execution speed, endurance and coordination skills [14, 15]. Concluding these definitions, we understand that coordination skills features are complexity, synergic action, and in the case of sporting games exceling under stress in challenging conditions.

Basketball has evolved significantly in terms of technique, tactics, requiring speed of play, and a high level of skilfulness. This evolution is due to the need of players to better solve the game concrete situations, in permanent dispute with the opponent [16] but also with the desire to overcome their physical limits.

In basketball, all basic factors of movement are part of the coordination skills in variable proportions – speed, force, resistance, eye – hand coordination, joint mobility, good sense of direction and other motor abilities [17]. The complex process of fast adaptation of the whole body to the game requirements have on its basis constant feedback between motor abilities, control, and level of fatigue.

In universities physical education classes, coordination skills can be exercised by using free or object-based exercises; practiced individually, in pairs or in teams. The exercises may be organized by means of relays, with ever-changing conditions and various difficulty levels.

The methodical steps needed to improve basketball-specific coordination skills and taken in physical education lessons may be:

- Ensuring the precision of technical procedures, as well as spatial orientation without regard to time; one evaluates the correctness of the movements done simultaneously with different parts of the body in order to perform the action;
- The correct and precise execution of all movements in order to perform technical procedures given in a short period of time;
- Performing movements in various and unusual situations, without mistake and while maintaining top speed. The entire process implies developing technical methods from a coordination point of view.

This study aimed at examining the effectiveness of a 14-week intervention in improving coordination skills among female university students. The intervention consisted in physical education lessons with basketball exercises, the final practical outcome being to practice a coherent and satisfying game for the players.

Materials and Methods

Participants

The research was carried out on a group of 15 female university students in first year in a faculty with economic profile, aged 19±0.28. The study began in the second semester of the academic year 2018-2019, lasted 14 weeks, with a frequency of 1 lesson per week. The inclusion criteria for eligible participation in the study group was that students have played basketball during their high school years.

Research design

The research design we considered relevant for our study was a pre-experimental one, with one group under intervention conditions [18]. Measurements were performed before intervention as a baseline and after it to record the effect size. The measurements were undertaken in the Bucharest University of Economic Studies' sport hall.

The manipulated variable was a physical exercises program designed in purpose to produce an effect on the dependent variable: coordination skills improvement. During the 14 lessons, the routine compiled:

Warming-up exercises:

- Walking or running exercises, alternated with power skips and bounding done in a certain rhythm
- Various running exercises, alternated with successive or isolated twirling
- From standing position: moving forward – backward with different arm movement for each step
- From standing position: raise on tiptoes, down on heels performed with different arm positions and movements
- Bending the torso in front and putting arms sideways
- From standing position, holding hands behind, tiptoe with eyes closed
- From standing position: left/right lunge while bringing left/right arm on the left/right shoulder behind the head, left/right arm sideways
- From standing position, arms up: four steps forward while rotating arms front-back at each step, four steps back with reverse rotation of arms
- Running over various obstacles with different heights, while maintaining the rhythm between two obstacles
- Rolling two balls, jumping from circle to circle, cone running drills – with cones placed at different positions and distances, with various combinations.

Lesson focus:

- From dribbling with left/right hand, the student throws the ball up in the air performs a 180° jump and then catches the ball before it hits the ground at the signal

- From pike position with the ball above ankles: the student throws the ball up with the feet and catches it in her hands;
- From slow running, dribble with left/right hand, guiding the ball around the body, then between the feet;
- Using two balls: throwing and catching the balls alternatively up or at the wall, as soon as the execution becomes better, balls can be thrown at the same time;
- Guiding the ball with the foot, while rotating the arms at the same time;
- With the back against the wall, holding a ball in the hands, throwing the ball at the wall from the hip area (or other ways of throwing), then face the wall and catch the ball;
- Exercises with multiple balls (passes and throwing at the hoop);
- Ambidextrous dribbling, passes and throws;
- Dribbling with two balls;
- Passes with both hands in front of the chest, both hands above the head, above the earth, with a hand on the shoulder, with a hand behind the back, shooting from the spot, then running and shooting while running;
- Perfecting dribbling during contra attack and during individual breaking-in and overrun – both ambidextrous;
- Complex exercises done on half the field and all over the field in order to perfect spot throwing at the hoop and while jumping;
- Catching the ball – stopping – dribbling – spot throwing at the hoop;
- Catching the ball – stopping – feint to throw – feint to overrun – dribbling – throw at the hoop;
- Catching the ball – stopping – feint – overrun with dribbling under the backboard – throwing with a hand;
- Going after the ball – catching – stopping – feint to throw – dribbling – stopping – feint to throw – throw at the hoop – rebound;
- Perfecting defending man to man, aggressive version and intercepting;
- Matches at the school level 5 against 5 on half the field and entire field.

Closing exercises

- Stretching exercises for flexibility improvement.

The research instruments were a battery of test conducted at the beginning (T1) and at the end of the study (T2), besides the 14 lessons and had the following tasks:

1. Dynamic balance – on a reversed gymnastic bench, the student walks over the distance with two 180° twirls at the middle of the bench and continuing the walk. Any imbalance is marked down a point. Falling leads to repeating the task. The tasks are executed twice, scores are given and the best attempt is picked.
2. Body coordination – a grid is drawn on the field's surface, the students perform 3 connected jumps – these should be as long as possible.
3. Hand coordination – a 25/25 cm square is drawn on a wall at a 1.5 m height. From a 2 m distance the student throws five balls with the right hand and five balls with the left hand. For each target hit, the student receives a point.
4. Basketball spot shooting – from under the backboard with the skilful hand, 10 throws. The score of successful throws were considered.
5. Dribble and throw from the dominant hand side – they are given points from 1 to 10 for technical correctness, correct step sequence and scoring.
6. Wall passes drill – on the left-side wall 4 squares are drawn at a 1.5 m distance from the floor and on the right-side wall, 3 squares are drawn at an equal distance. The female student dribbles from the end of the hall towards the left-side wall, performs passes at the wall from a 3 m distance, then dribbles towards the right-side wall and performs a wall pass and repeats at all the 7 points. The task is timed.

Statistical Analysis

During our research, the data obtained through measurement and tests has been statistically processed and charted aiming the hypothesis validation through mean difference between pre and post-tests and determine the effect size using t-Test Dependent Student calculated for a statistical significance of $p<0.05$ level. The effect size was compared with Cohen scale. In data analysis SPSS software was used.

Results

The results obtained before (I) and after (F) intervention at all 6 tasks were tabulated in Table 1.

The statistical processing data obtained can be seen in table 2. The most relevant results are presented. Among them are the progress percentage, the effect size and the t-Test results compared with the critical t value (2.14)

Discussion

The most recommended period for developing coordination skills is in childhood between 5 and 6 years of age and then in preadolescence between 10 and 13. However the highest values of coordination skills can be reached between 17 and 20 years of age. Following this idea, a number of studies have obtained good results in developing coordination abilities in samples of university students [19, 20]. It demonstrates that development of coordination abilities is an overgoing process.

After analyzing and interpreting the data presented in Table 2, we observe an important improvement in all final tests. The highest improvement percentage was observed in the Spot

Table 1. The results obtained

No.	Dynamic balance		Body coordination		Hand coordination				Basketball spot shooting (%)		Dribble and throw		Wall passes (sec.)	
					Right		Left							
	I	F	I	F	I	F	I	F	I	F	I	F	I	F
1	7	8	4.20	4.82	4	5	2	3	20	20	8	9	21	19
2	8	9	4.10	4.26	3	4	3	3	30	40	6	7	23	20
3	6	7	4.55	4.83	3	4	4	5	40	50	5	7	20	16
4	8	10	5.57	5.67	3	4	3	3	20	40	6	7	22	21
5	7	8	4.00	4.07	4	4	3	4	30	50	5	6	21	19
6	7	8	5.10	5.69	4	5	4	5	50	70	5	6	23	20
7	7	8	4.10	4.60	4	5	4	5	50	60	6	7	22	21
8	8	9	5.02	5.52	4	5	3	4	40	50	6	6	20	17
9	7	7	3.80	4.02	1	1	1	2	20	30	5	7	22	22
10	9	10	4.00	4.18	3	3	0	0	20	30	6	7	24	23
11	7	8	4.12	4.54	3	4	2	3	20	20	5	7	23	22
12	6	7	4.90	5.04	3	4	4	4	30	30	6	7	20	18
13	9	10	4.57	4.72	4	5	3	4	30	40	6	8	20	19
14	8	8	5.00	5.20	3	3	4	4	30	40	6	8	17	16
15	8	10	3.80	4.88	3	4	4	5	60	70	6	6	19	17

Table 2. Statistical processing data

Statistical indicators	Dynamic balance		Body coordination		Hand coordination				Basketball spot shooting (%)		Dribble and throw		Wall passes (sec.)	
					Right		Left							
	I	F	I	F	I	F	I	F	I	F	I	F	I	F
Upper limit	9	10	5.57	5.69	4	5	4	5	60	70	8	9	17	16
Lower limit	6	7	3.80	4.02	1	1	0	0	20	20	5	6	24	23
Amplitude	3.00	3.00	1.77	1.67	3.00	4.00	4.00	5.00	40	50	3	3	7	7
Mean	7.47	8.47	4.46	4.80	3.27	4.00	2.93	3.6	32.67	42.67	5.80	7.00	21.13	19.33
Standard deviation	0.92	1.13	0.55	0.55	0.8	1.07	1.22	1.35	0.72	0.94	0.7	0.85	2.43	2.23
Coefficient of variation (%)	12.26	13.29	12.29	11.44	24.45	26.73	41.69	37.56	12.42	16.23	10.0	12.07	12.58	11.51
Mean difference	1.00		0.34		0.73		4.13		10.00		1.2		1.8	
Progress (%)	13.39		7.8		22.45		22.73		30.61		20.69		9.31	
Effect size	1.87		1.27		1.6		1.37		3.31		1.7		0.74	
Test Student (critical t =2.14) p<0.05	7.25		4.92		6.20		5.29		12.78		3.18		4.77	

shooting test: 30.61%.

In the Dynamic balance test the average raise was 13.39%, while in the Body coordination test (3 connected jumps) we observe a 7.8% average raise. In both Hand coordination tests (right and left) the improvements were almost equal: 22.45% for the right hand and 22.73% for the left hand. In the Dribble and throwing test where students were given marks from 1 to 10, we can observe a 20.69% average raise at the final test. Also, in Wall passes drill the mean progress was of 1.8 s, representing a 9.31% better results.

The t-test value is higher than critical t's value for all the 6 battery tests' as it can be seen in table 3. Consequently, the null hypothesis is rejected and the hypothesis of this study is validated.

The effect size calculated is between 0.74 in wall passes drill test and 3.31 in spot shooting test. These values were compared with Cohen effect size index where d=0.2 is considered to be small; 0.5 medium; 0.8 large and 1.3 very large [21]. Effect size calculated in 5 of 6 tests are verry large and in one case (wall passes) the effect size is verry close to the large level. The largest size effect was obtained in Spot shooting test, ability which is decisive in achieving a satisfactory basketball play and scoring possibility.

Our experience in physical education lessons has confirmed that fatigue may occur in lessons with excessive focus on intense training. Therefore, it is recommended to give quite long breaks between series – especially in the second part of the lesson [22], otherwise the students' ability to develop transferable athletic skills may be impeded.

The deciding factor in formation, development and master of coordination skills is the method of repeating through continuous and progressive diversification of motor actions in compliance with the characteristics and means that are specific to the targeted level. In basketball case, we recommend teaching the overall technical procedures, as well as using several well-known exercises to make the process of developing coordination skills more accessible.

Our study findings are consistent with recent pedagogical experiments on female university students attaining physical education classes. In two cases the intervention consisted in choreography [23] and dance [19] exercises and there were effective in developing the coordination skills. Another study on the same age range and gender [20] demonstrated that the coordination skills are more likely to be improved compared to speed as a skill related fitness component. Furthermore, in basketball as a team sport, a high level of coordination abilities is a prerequisite for improvement of the technique and tactic of the game.

Conclusions

Using the means specially designed to develop coordination skills has led to very good results, which have positively influenced the learning process of playing basketball. Coordination is the function that constrains the potentially free variables into a behavioral unit, while skill is the optimal manifestation of this function. The coordination skills developed can be transferred in everyday life and lead to a substantial improvement of overall life quality.

Following the results in all 6 tests, we observed a significant statistical improvement at the final test, which proves that the study's hypothesis has been validated. Also, the effect size in 5 of 6 tests was very large and in the 6-th test, the result is near the large threshold.

From the teaching experience gathered throughout the study, we have concluded:

- Learning and perfecting technical procedures is conditioned by the level of the coordination skills displayed;
- High level of coordination skills allow the performance of motor actions in various situations;
- High level of coordination skills allow superior valorization of other motor skills.

The instructive-educative process features are a low volume of effort, with exercises placed in the

Table 3. Research hypothesis

Item No.	Test	Initial	Final	Observation	Effect	Study hypothesis
1	Dynamic balance	7.47	8.47	13.39% raise	V. Large	Accepted
2	Body coordination	4.46	4.80	7.8% raise	V. Large	Accepted
3	Right hand coordination	3.27	4.00	22.45% raise	V. Large	Accepted
4	Left hand coordination	6.66	6.92	22.73% raise	V. Large	Accepted
5	Basketball spot shooting	32.67	42.67	30.61% raise	V. Large	Accepted
6	Throwing the ball while dribbling	5.80	7.00	20.69% raise	V. Large	Accepted
7	Wall passes	21.13	19.33	9.31% raise	Large	Accepted

*p<0.05

beginning of the lesson to assure a good mobility in the nervous system.

Limitations

We understand that the modest number of cases in this study may be an issue, but despite this limitation the result encourages us to believe there are chances to improve coordination skills in physical education of university students.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. Kimura A, Yokozawa T, Ozaki H. Clarifying the Biomechanical Concept of Coordination Through Comparison with Coordination in Motor Control. *Front. Sports Act. Living*. 2021; 14 (3):753062. https://doi.org/10.3389/fspor.2021.753062
2. Grigore V, Mitrache G, Predoiu R, Rosca R. Characteristic of instrumental movement-eye hand coordination in sports, *Procedia-Social and Behavioral Sciences,* 2021;33:193–197. https://doi.org/10.1016/j.sbspro.2012.01.110
3. Moanță A. *Physical Training in the Basketball Game*. Bucharest: Pro; 2000. (In Romanian).
4. Nae IC. *The technique of playing basketball in physical education lessons in higher education.* Bucharest: ASE; 2010. (In Romanian).
5. Schnabel G, Meinel K. *Theory of movement: synthesis of a theory of motor sports under the pedagogical aspect*. Buenos Aires: Stadium; 1987.
6. Hirtz P. *Objectives, means and methods of coordination improvement*. Italy: Athletics; 1986.
7. Blume DD. Identification of coordinative skills and capabilities, their development. *Wissenschaftliche Zeitzchrift der DHfK*, 1981; 3: 17–41.
8. Manno R. *Motor skills*. The Romanian Sports Scientific Society; 1982.
9. Weineck J. *Manuel d'entrainement* [Training manual]. Paris: Vigot; 1986. (In French).
10. Dragnea A. *Theoretical and methodical sports training*. Bucharest: FEST; 1999.
11. Colibaba ED, Bota I. *Sports games, theory and methodology*. Bucharest: Aldin; 1998.
12. Bompa TO. *Development of biomotor qualities*. Constanta: Ponto; 2001.
13. Baştiurea E. *Handball. Concepts, principles, and ways to improve training*. Galati: Academica; 2007.
14. Peper CE, Betteco JB, Harjo JP, Peter J. B. Interlimb coupling strength scales with movement amplitude. *Journal of Neuroscience letters*, 2008; 437:10–14. https://doi.org/10.1016/j.neulet.2008.03.066
15. Baştiurea E, Stan Z, Rizescu C, Mihăilă I, Andronic F. The effect of muscle strength on the capacity of coordination in handball, *Procedia-Social and Behavioral Sciences*, 2014; 137: 3–10. https://doi.org/10.1016/j.sbspro.2014.05.244
16. Hantău C. *Volleyball - Basic theoretical notions*, Bucharest: A.S.E.; 2014.
17. Reijo B, Caroline N, Pavoo VK, Vesa L. Adaptive changes in motor control of rhythmic movement after maximal eccentric actions. *Journal of Electromyography and Kinesiology*, 2009; 19: 347–356. https://doi.org/10.1016/j.jelekin.2007.09.001
18. Lopez Bernal JA, Andrews N, Amirthalingam G. The Use of Quasi-experimental Designs for Vaccine Evaluation. *Clinical Infectious Diseases*, 2019;68:1769–76. https://doi.org/10.1093/cid/ciy906
19. Limanskaya O, Yefimova O, Kriventsova I, Wnorowski K, Bensbaa A. The coordination abilities development in female students based on dance exercises. *Physical Education of Students*. 2021;25(4):249–56. https://doi.org/10.15561/20755279.2021.0406
20. Nagovitsyn RS, Osipov AYu, Manurov IM, Zhuikov RA, Vershinina NB. Adaptation of foreign female students to physical activity based on the dexterity development. *Physical Education of Students*, 2019;23(2):70–74. https://doi.org/10.15561/20755279.2019.0203
21. Sullivan GM, Feinn R. Using Effect Size—or Why the *P* Value Is Not Enough. *Journal of Graduate Medical Education*, 2012;4:279–82. https://doi.org/10.4300/JGME-D-12-00156.1
22. Nae IC. Theoretical and practical aspects regarding forming representative university basketball teams. *Marathon*, 2019;11 (2): 92–97.
23. Radaeva SV, Bezhentseva LM, Sosunovsky VS. The Use of Choreographic Exercises for the Development of the Conditioning and Coordination Abilities of Female University Students. *Tomsk State University Journal,* 2021;465:172–178. https://doi.org/10.17223/15617793/465/23

Information about the authors:

Cristina I. Nae; (Corresponding Author); https://orcid.org/0000-0003-1429-4380; ionela.nae@ase.ro; Department of Physical Education and Sports, Bucharest University of Economic Studies; Bucharest, Romania.

Cristiana L. Pop; https://orcid.org/0000-0002-6445-8702; cristina.pop@defs.ase.ro; Department of Physical Education and Sports, Bucharest University of Economic Studies; Bucharest, Romania.

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CONTACT INFORMATION

box 11135, Kharkov-68, 61068, Ukraine
phone. +38 099 430 69 22
http://www.sportpedu.org.ua
e-mail: sportart@gmail.com

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