ISSN: 2148-1148

IntJSCS

International Journal of Sport Culture and Science (IntJSCS)

International Refereed Scientific Journal

Volume 11 Issue 2
June 2023

cross ref <enabled>

doi

International Refereed Scientific Journal

June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS

www.iscs-a.org

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.675

EFFECT OF AEROBIC EXERCISE ON STRESS AND THE BRAIN-GUT AXIS

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Type: Research Article (Received: 14.10.2022 – Accepted: 30.05.2023)

Abstract

The aim of this study is to examine the effects of aerobic exercise on stress and brain-gut axis in individuals. Twenty adult individuals who did not exercise regularly before, were 18 years of age and older, had no barriers to aerobic exercise, actively used e-mail addresses and agreed to participate in the study voluntarily participated in the study. The participants were given an aerobic exercise program (exercises such as light-moderate walking, cycling and swimming in the open air), 3 days a week, for a total of 5 hours, without being divided into any groups. Individuals were asked to fill in a 10-item perceived stress scale and a brain-gut axis inquiry form, which included 46 questions, after performing aerobic exercise before and at the end of aerobic exercise. The data obtained were evaluated in the SPSS version 26.0 package program. A significant difference was found between the pre-test and post-test results in terms of the perceived stress and the effects on the brain-gut axis of individuals performing aerobic exercise. While the decrease in the stress subunit of the brain-gut axis questionnaire form was 7.23%, the decrease in the stress perception scale was 22.73%. As a result of the study, it can be suggested that aerobic exercises can reduce the perception of stress in individuals and has the potential to affect the brain-gut axis. The stress subunit of the brain-gut axis also decreased, albeit less in percentage. It can be said that 1 week of aerobic exercise affects the perception of stress more than the brain-gut axis.

Keywords: Aerobic exercise, stress, brain-gut axis

Introduction

The gastrointestinal tract is one of the most important systems of the human body. In this system, 80 to 100 trillion bacteria live and form the human intestinal flora (microbiota) (Mayer, 2017). Each individual has a unique gut microbiota. This microbiota is affected by various factors and differs in each individual. According to the literature, it has been shown that even identical twins have different gut microbiota (Nazlıkul, 2018; Önsü and Tezcan, 2018). Bacteria diversity is highest in the intestines and least in the stomach, respectively. Almost all of the bacteria (95-98%) in the microbiota of healthy individuals are beneficial bacteria and they live in a symbiotic relationship (Erdoğdu, 2016). Intestinal flora is associated with many factors. These; genetic factors, stress, antibiotics, mode of delivery (cesarean/vaginal birth), age, exercise and nutrition (Mayer, 2017). Intestinal flora has many positive effects on human health. These; It has an important role in preventing the formation of harmful bacteria in the gastrointestinal tract, ensuring the pre-digestion of B vitamins, and the production and secretion of neurotransmitter substances, which are necessary chemicals for the brain (Junger, 2018). Nutrition plays a key role in regulating the gut microbiota. Namely, Mediterranean-style diet, fibrous and vegetable high-protein foods affect the microbiota positively. However, excessive consumption of carbohydrates and fats, use of processed and packaged foods, stress, sedentary life, smoking and alcohol use affect the intestinal microbiota quite negatively (Coşkun, 2006; Bressa et al., 2017). Exercise and active lifestyle has been thought to have positive effects on the microbiota (Bressa et al., 2017). Looking at the literature, in general, a balanced and regular diet as well as regular aerobic exercise increases the diversity of intestinal flora. For this reason, our primary aim in our study is to examine the effect of aerobic exercise on stress and brain-gut axis in individuals.

Material and Method

The population of the study consisted of individuals living in Istanbul between April and June 2021. The research sample included individuals who were 18 years of age and over, who did not have any obstacles to aerobic exercise, actively used their e-mail addresses and voluntarily accepted to participate in the study between April and June 2021. Individuals who were 18 years of age or younger, had any condition that prevented them from doing aerobic exercise, did not actively use their e-mail address and did not voluntarily agree to participate in the study were not included in the study. Power analysis was used to determine the sample size.

Cochran's known population size formula was used to calculate the sample size ($n=(Nt^2pq)/(d^2(N-1)+t^2pq)$). According to this formula, at least 12 participants should be included in the minimum sample size to be reached in our study with an error of $d=0.05$ at 95% ($\alpha=0.05$) confidence interval limits. In order to show the relationships between variables more clearly, the study was completed with 20 individuals.

Participants

20 adult individuals who did not exercise regularly before participated in the study. The participants were given an aerobic exercise program, 3 days a week for a total of 5 hours, without being divided into any groups. Individuals who are 18 years of age or older, who do not have any obstacles to doing aerobic exercise, who actively use e-mail addresses and who voluntarily agree to participate in the study were included in the study. Individuals who are 18 years of age or younger, who have any obstacles to aerobic exercise, who do not actively use an e-mail address and who do not agree to voluntarily participate in the study are not included.

Scales

Perceived stress scale (PSS): The PSS was developed by Cohen, Kamarck and Mermelstein in 1983 to self-assess the level of stress experienced depending on the extent to which the respondent evaluates his/her life as unpredictable, uncontrollable and overloaded. In our country, the Turkish validity study of this scale was conducted by Yerlikaya and İnanç in 2007. In this scale, in which the relationship between sense of humor and stress was examined, individuals were asked to evaluate the degree to which they experienced their feelings and thoughts in the last month. Scoring was asked to be evaluated between 0 and 5, with 0 (not at all) and 5 (very much). The total score of the participants determines their perceived stress level. The higher the score, the higher the perceived stress level.

Brain-gut axis inquiry form: Created by Vagustim, a company that produces a wearable medical technology device. The cerebrointestinal axis questionnaire consists of 46 questions. In addition to demographic data of the participants such as age, gender, height and weight, there are questions under the headings of autonomic nervous system, gastrointestinal system, nutrition and stress. The evaluation of the brain-gut axis questionnaire form is performed by Vagustim software.

Procedure

Before the aerobic exercise, the participants were asked to fill in the perceived stress scale with 10 questions and the brain-gut axis inquiry form, which included 46 questions. Individuals who filled out the scale and form were given an aerobic exercise program, 3 days a week, for a total of 5 hours. The mentioned aerobic exercise program includes outdoor exercises such as light-moderate walking, cycling and swimming. At the end of 1 week, the participants who applied the aerobic exercise program were asked to fill in the perceived stress scale and the brain-gut axis inquiry form again.

Analysis of Data

Data were analyzed using SPSS version 26.0 (IBM Corp) package program. Data are reported using number, percentage and arithmetic mean.

Results

Table 1. Results of brain intestinal axis evaluation form (N=20)

	Stress (%)	Nutrition (%)	GIS (%)	OSS (%)
Before Aerobic Exercise	33,61	24,57	22,72	19,10
After Aerobic Exercise	31,18	27,21	21,14	20,45

Looking at the data, the problems in the brain-gut axis of the participants before aerobic exercise are mostly related to stress (33.61%). Stress is followed by nutrition (24.57%), gastrointestinal system (GIS) (22.72%) and autonomic nervous system (ANS) (19.10%) components, respectively. The brain-gut axis survey consists of 4 main components and a score close to 25% is expected in each component in healthy individuals. As the score goes above 25%, it shows that the problem in that component of the axis is high. After individuals perform an aerobic exercise program for 3 days a week for a total of 5 hours, problems in the brain-gut axis again are mostly related to stress (31.18%). However, when compared with the previous data, there was a 7.23% reduction in the stress rate after aerobic exercise. Nutrition (27.21%), gastrointestinal system (GIS) (21.14%) and autonomic nervous system (OSS) (20.45%) components scores were also obtained in this way. In addition to stress, when the data is compared before and after aerobic exercise, there is a 6.97% decrease in the rate of GIS, while the rate of nutrition and ANS problems are increased 10.76% and 7.06%, respectively (Table 1).

Table 2. Perceived stress scale scores of individuals before aerobic exercise (N=20)

	Very Often (%)	Frequently (%)	Sometimes (%)	Hardly Ever (%)	Never (%)
How often in the past month, have you been upset by unexpected events?	27,3	31,8	31,8	9,1	0
How often in the past month have you felt that you can't control the important things in your life?	18,2	36,4	40,9	2,3	2,3
How often in the past month have you felt tense and stressed?	45,5	27,3	25	2,3	0
How often in the past month have you been confident in your ability to cope with your personal problems?	2,3	29,5	50	18,2	0
How often in the past month have you felt that things were going the way you wanted?	2,3	34,1	43,2	15,9	4,5
How often in the past month have you felt that you couldn't handle everything you had to do?	9,1	20,5	59,1	6,8	4,5
How often in the past month have you been able to control the disturbing events in your life?	0	15,9	61,4	20,5	2,3
How often in the past month have you felt in control of events in your life?	4,5	31,8	40,9	20,5	2,3
How often in the past month have you been angry because of things that were out of your control?	22,7	34,1	36,4	4,5	2,3
How often in the past month have you felt that the difficulties have become so numerous that you cannot cope?	27,3	22,7	40,9	2,3	6,8

Table 3. Perceived stress scale scores of individuals after aerobic exercise (N=20)

	Very Often (%)	Frequently (%)	Sometimes (%)	Hardly Ever (%)	Never (%)
How often in the past month, have you been upset by unexpected events?	13,6	15,9	31,8	31,9	6,8
How often in the past month have you felt that you can't control the important things in your life?	6,8	20,5	38,6	27,3	6,8
How often in the past month have you felt tense and stressed?	11,4	15,9	34,1	38,6	0
How often in the past month have you been confident in your ability to cope with your personal problems?	2,3	40,9	45,5	9,1	2,3
How often in the past month have you felt that things were going the way you wanted?	0	40,9	47,7	9,1	2,3

How often in the past month have you felt that you couldn't handle everything you had to do?	0	18,2	45,5	29,5	6,8
How often in the past month have you been able to control the disturbing events in your life?	2,3	47,7	43,2	4,5	2,3
How often in the past month have you felt in control of events in your life?	4,5	40,9	43,2	9,1	2,3
How often in the past month have you been angry because of things that were out of your control?	13,6	11,4	40,9	22,7	11,4
How often in the past month have you felt that the difficulties have become so numerous that you cannot cope?	4,5	15,9	50	27,3	2,3

The scores of the Perceived Stress Scale before and after exercise protocol are written in Table 2 and 3.

Table 4. Perceived stress scale total score before and after aerobic exercise (N=20)

	Before Aerobic Exercise	**After Aerobic Exercise**
Perceived Stress Scale (PSS) Score	22	17

The total scores of the perceived stress scale range from a minimum of 0 to a maximum of 40 points. When the scores are added together, the higher the score, the higher the perceived stress level of the individual. Considering the data, there is a decrease of 22.73% in the total score of the perceived stress scale applied to individuals before and after aerobic exercise (Table 4).

Discussion and Conclusion

In this study, it was tried to evaluate the effect of a total of 5 hours (3 days a week) of aerobic exercise program (exercises such as outdoor, light-moderate walking, cycling, swimming) on individuals' perceived stress and brain-gut axis. When the pre-test and post-test results were examined, it was thought that exercise might have positive effects on stress and can affect the brain-gut axis by decreasing stress. According to a study by Cerdá et al. in 2016, moderate physical exercise was found to be effective in increasing microbiota diversity. In a study conducted by Barton et al. in 2018 comparing professional rugby players and sedentary individuals, it was suggested that exercise increases the production of short-chain fatty acids formed by the microbiota and therefore positively affects gut health. According to studies conducted on mice, it has been found that when the microbiome taken from the stressed mouse is given to the healthy mouse, the stress level of the healthy mouse also increases significantly (Bercik et al., 2011; Heijtz et al., 2011; Sudo et al., 2004).

According to a recent study in the literature, it was found that there is a significant decrease in the stress level when the gut microbiota is improved. In this study, in which the effect of aerobic exercise on stress and brain-gut axis in individuals was examined, it was thought that aerobic exercises affected the brain-gut axis, and reduction was seen in stress and anxiety levels (Katasonov, 2021). Looking at the study of Babaoğlu and Özdenk in 2017, it is found that there is a significant relationship with irritable bowel syndrome in individuals with high stress levels. Özer et al. (2019) found that stress causes some metabolic disruptions by affecting the gut microbiota. The effect of stress on the brain-gut axis varies depending on external factors such as antibiotics and nutrients. Considering our study, it was seen that 1 week of aerobic exercise could cause a decrease of 22.73% in the total score of the perceived stress scale. The decrease in the stress subunit of the brain-gut axis questionnaire form (7.23%) was lower than the decrease in the stress perception scale. This may be due to the difference in the assessment of stress in the questionnaires. In addition, it can be thought that the decrease in stress is not fully reflected in the brain-gut axis within 1 week.

Since there are not many studies investigating the effects of exercise on stress, anxiety and quality of life in the literature, more scientific studies are needed on these issues.

Credit Author Statement

Study concept/design: HD, MB, AVO; Data collection/data processing: HD; Data analysis and interpretation: HD; Manuscript drafting: HD; Critical review of content: HD, MB, AVO; Final approval and responsibility: HD, AVO; Technical and material support: None; Supervision: AVO.

Conflict of Interest

There is no conflict of interest between the authors.

Funding Information

The budget of the study was covered by the researchers.

Acknowledgement

We thank the participants who voluntarily agreed to participate in this study.

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.676

Effectiveness of Video Simulation Training on Coincidence Anticipation Timing for Law Enforcement Officers

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Type: Research Article (Received: 22.05.2023 – Accepted: 05.06.2023)

Abstract

Objectives: To examine the coincidence anticipation timing performance of law enforcement officers before and after four consecutive weeks of completing a video simulation intervention. Design: A one group pre/post study design (n =15) was selected for this investigation. Methods: 15 healthy police officers (13 men, 2 women; age 39±1.7 years; height 175.28±12.72 cm; weight 88±25.4 kg) from a Midwest law enforcement agency were selected for the study. The Bassin anticipation timer was used in this investigation. The object stimulus speed was set at 3.0 mph in accordance with prior studies. Participants were allowed a single practice trial on the anticipation timer before the 3 trial attempts, both pre and post. The anticipation timer was placed approximately two feet in front of the participant on a table with the target light marked, and in view of each subject. The Virtra, a 300° video simulator was selected as the intervention. Each participant performed a new video simulation two times per week for 4 consecutive weeks. Results: A dependent t-test (SPSS ver. 26) determined a significant relationship (p = 0.035) between pre and post test scores after 4 weeks. Conclusion: Coincidence anticipation timing improved with police officers within 4 weeks when training with a VirTra video system twice a week, for 4 consecutive weeks. This could potentially improve decision-making for police officers.

Keywords: Police, VirTra, Coincidence Anticipation Timing, Video Simulation, Target Tracking

Introduction

Law enforcement officers can be faced with fast-paced, high stress situations when on duty. Working in law enforcement can be a high-risk job due to the level of violence that each officer faces each day which results in a higher rate of injuries and death compared to other professions (Orr et al., 2023; Thompson et al., 2017; Tiesman et al., 2018). Since the first recorded fatality of a police officer in 1786, there has been over 22,000 officers killed in the line of duty (Bennell & Jones, 2004). Police officers can be tasked with the act of having to respond quickly, with little to no warning in response to offenders or other environmental stimuli. The period from the unanticipated, unexpected stimulus to the onset of the movement is known as reaction time (Ross et al., 2022). Reaction time is an important skill for police officers to have, for the protection of themselves, their colleagues, and the public. When an object is being tracked or intercepted, this is known as coincidence anticipation timing (Le et al., 2022; Ross et al., 2022). Coincidence anticipation timing (CAT) is a skill that allows an officer to be able to think, react, and perform a proper response within a period that is conducive towards one's safety.

The ability to make quick decisions that are perceived as threatening are known as neurological and physiological processing (LeDoux & Pine, 2016). Decision-making is a critical part of activities of daily living, including police officers. This action comes from the portion of the brain known as the cerebellum (Poldrack & Farah, 2015). By optimizing how the brain perceives and responds to stimuli, we can become better decision-makers, problem solvers, and overall, more safety conscious (Andersen et al., 2020; Le Doux et al., 2016). Improving the ability to make quick decisions and be able to act on those decisions with accuracy requires specific training. In law enforcement, it is critically important to read the scenario and recognize what actions need to happen in any given scene which could result in injury or even death. Improving CAT in police officers could result in an increase in longevity and a decrease in the injury rate of police officers. In a previous study performed by Duncan et al. (2015), video simulation training demonstrated an increase in shooting accuracy skill but suggested that there is a still a need for future research to develop officer training and decision training.

Video simulators have been used since 1992 for military and law enforcement agencies, however, past literature is limited (Bennell & Jones, 2004; Latham et al., 2013). The Canadian government developed a manual dictating about the advantage of how simulators can be useful for decreasing court cases. These videos create the ability to make better decisions on possible violent outcomes by police officers and military personnel. The scenes are created to promote cognitive awareness and provide different outcomes, based on the choices that have led to lawsuits and court hearings. Video simulators have also demonstrated improvement in making better decisions that result in healthier outcomes (Tailby & Haslam, 2003). It has been proven that engaging students with hands-on instructional practice is more effective than exposing them to the content with static visual aids (Tailby & Haslam, 2003). Due to these past studies, video simulation may play an effective role in improving cognitive skill development and accuracy for anticipation timing.

Therefore, the purpose of this study was to determine if video simulations performed on a moving video system could improve CAD in law enforcement officers.

Material and Methods

A one group, based on convenience, pre- and post-test experimental design was selected for the study. Fifteen volunteers (13 men, 2 women; age: 39±1.7 years; height: 175.28±12.72 cm; body mass: 88±25.4 kg) police cadets from a Midwest law enforcement agency voluntarily served as the participants. All participants were healthy subjects based on their recruit applications and completed an informed consent form. This study proposal was approved by the Midwest institution's Institutional Review Board (IRB approval number: CSM 2013).

After the participants agreed to take part in the study, the data collection began with recording of subject demographic information such as weight, height, age, and BMI. A pre-test for CAT, using a Bassin Anticipation Timer (Model 35575 Lafayette Instruments, Lafayette, IN) was conducted before the video intervention. Participants began with verbal instructions on how to properly use the Bassin Anticipation Timer. This device had the participants watching a moving light on a runway. The subject was instructed to anticipate when the moving light would land on the indicated target spot by pressing the toggle push button. This valid and reliable device accurately measures a participant's anticipation time to one 1000th of a second (Coker, 2006) may they be early or late. This assessment was selected as the method for measuring CAT based on visual feedback that is necessary in making decisions on moving objects. Each participant was given one practice attempt with the timer to become familiar with the motion of the light moving down the runway. The timer had a speed setting of 3.0 miles per hour based on previous studies performed on adults (Coker, 2006; Duncan et al., 2015; Le et al., 2022). All participants were given three trials, attempting to perform as precisely as possible to hit the target. Three attempts were recorded and calculated to determine the average of the three scores.

After the pre-test scores were recorded, participants completed a video simulation intervention for 4 consecutive weeks, twice per week. The VirTra (V-100 model, Tempe, AZ), is a 300° video simulator, that allows real-life video siuations as well as animated object target shooting by using a standard Glock 9 mm handgun loaded with gas powered lasers. The simulator allows movement of the participant in a standing enclosure and provides accurate feedback of where a shot landed. With certain features, the live scenes change each scenario, so although similar, it is different and unexpected each time. The given simulation was chosen by the indoor gun range officer based upon scenarios that had movement of objects, therefore promoting movement interception. The participants did not know the type of video simulation beforehand to eliminate any maturation from previous experience. Each participant had no previous knowledge with the type of video shooting simulations before their participation in this study. The accuracy score of each VirTra simulation score was recorded after each attempt. The CAT post-test was administered after the four consecutive weeks of the VirTra video intervention. After the data was recorded, the post-test scores were compared to the pre-test scores.

A dependent t-test using SPSS (SPSS ver. 26), a data analysis software, was used to observe the difference in mean scores between the group, the pre-test scores, and the post-test scores from the Bassin Anticipation Timer. An alpha $p < 0.05$ was set, allowing the confidence level to be at 95%. Effect size interpretation was set as small for ≤ 0.2, medium for 0.5, and large for ≥ 0.8 (Cohen, 1988; Larner, 2014).

Table 1. Group Pre and post test means along with effect size

Table 1. Pre/Post CAT

Bassin Anticipation Timer Trials	CAD Pretest		CAD Posttest				
	M	*SD*	*M*	*SD*	*t(13)*	*p*	*Cohen's d*
CAT 1	0.057	0.050	0.041	0.044	1.36	.099	0.36
CAT 2	0.059	0.046	0.036	0.026	1.83	.046	0.49
CAT 3	0.050	0.038	0.034	0.031	1.21	.124	0.32
Average CAT	**0.056**	**0.035**	**0.037**	**0.025**	**1.93**	**.038***	**0.52**

Findings

The six shooting intervention scores had a lowest mean of 62.7 and a highest score of 96.3. The average standard deviation for shooting scores was 8.27. By observing trial 1 of the CAD pretest (Table 1) there is a mean of 0.057 seconds. The third attempt had an improved mean of 0.050 seconds. The average between the three pretest scores was 0.056. By observing trial 1 of the CAD posttest, the mean was 0.041. The third attempt also had an improved mean of 0.034 seconds. The average between the three posttest scores was 0.035 seconds. Cohen's d demonstrated a moderate effect size, (0.52) among the sample population.

Discussion

This novel investigation was one of the very first to be conducted worldwide, assessing CAT with police officers. This study examined using a video intervention of objects or scenes and attempted to determine if this 4-week intervention could allow police officers to improve on CAT scores. In a study with a similar sample size of nineteen subjects, Alen (2015) proved that consistent exposure to video games improves a person's anticipation of a coincidence task. Video games have been used as an intervention since the mid-1980s for improving cognition, memory, and decision-making (Young, 2008). Alen's use of video games supports the results from our current study based on the pre to post CAT scores after the 4-week video intervention. Alen's results were promising because it supported the idea that video games could improve information processing speed and require the participant to track objects visually throughout a process of continual movements. This improved their ability to effectively shift their attention from a stationary stimulus to a moving target, such as the VirTra video system. Latham, Patston & Tippett (2013), also supported the idea that playing video games consistently improves visual attention, executive control, and reaction times. Kuhlman and Bierel (1991) also purported similar findings of video game players who were able to anticipate stimulus onset very accurately over several weeks. Their ability to track with their eyes gave them the benefit of having a more accurate response to the correct stimulus in a sequence. As a result, this allows them to anticipate the arrival of the light stimulus successfully. Alen (2015) noted how the improvements in visual attention, anticipation timing and control remained to at least five months past the time the participants were studied. This could provide some explanation as to the improvements in CAT performance for the current studies' participants.

Helsen & Starkes (1999) used a larger sample size (n = 24) when assessing police officers with shooting efficiency. Their study used a slide and a projector screen of pre-recorded video scenarios, much more archaic than the video intervention our study used. Their investigation was extremely important at the time, setting the standard towards using video interventions to improve proper responses among police officers. Their use of multiple screens that rotate scenarios throughout the intervention was considered state of the art and the beginning of using video interventions with law enforcement. Since this inaugural revelation twenty years ago, newer electronic versions, such as the VirTra have created more life-like situations and can distribute important data. VirTra uses real-life scenarios as well as moving targets that allow a participant to track an object and be able to make good decisions on when to fire their gun. Our intervention allowed for object interception, whereas the older screen versions did not. Helsen & Starkes' study also used an initial signal to prepare them for a stimulus, allowing them to anticipate the scenario that was about to occur. This was much different than our study, where a preparatory signal did not occur, however, each police officer was given a visual three second countdown as to when the scenario was going to start. Another point to consider that differentiated this study from ours would be the use of actual weapons provided by each participant. A Glock 9 mm, outfitted with a laser and interfaced to the computer software system provides more real-life environments. Comparatively, the investigators for our study used the same exact handgun for each participant, each day the scenarios were run. Helsen & Starkes (1999) used a ten-point scale to rank each result subjectively. This probably caused interrater reliability errors since their scores were assessed by a different person. This is unlike our current study where all measures were objective and not ranked. With the improved development of new technology, the VirTra system provided shooting scores to assess shooting performance. The equipment used along with the video system allowed the scores to be more objective and congruent throughout the four-week intervention. Our study also differentiated from other previous studies by not looking at accuracy scores but observing if the intervention improved anticipation timing specifically (Boyd, 1992). The CAT pre-test and post-test scores showed drastic improvement, Table 1, supporting the idea that learning from videos with moving targets can be most effective towards improving the decision-making process.

The skill of mastering motor and cognitive skills can be accomplished with repetitions (Bennell & Jones, 2004). Handling a firearm and making split second decisions allows for no room for error. To achieve this skill, the officers must repeat the task multiple times. In our study the officers performed the intervention of the shooting scenarios, twice a week for four consecutive weeks. The time of exposure and variety of scenarios were sufficient to improve CAT over the 4-week intervention. It demonstrates that mastery of skill is required to make safe and could possibly result in providing better decisions when in a high stress situation, leading to improved officer safety. Future video intervention studies with increased sample sizes as well as improving gender ratios and including older police officers could potentially offer more insight towards the benefits that our study has demonstrated.

Coker (2006) examined and demonstrated how efficient anticipation timing can be achieved by conducting a study on a variety of methods to track a target light. Coker's study is similar in such that it examines variables related to CAT, using an identical instrument, the Bassin Anticipation Timer. However, our study used a VirTra video system in addition to the timer, which is relatively new and used for military and law enforcement officers, but has limited data, therefore allowing our study results to demonstrate possible officer safety and improve judgement.

Conclusion

The current study gives support to previous studies showing that video could be an efficient method for enforcement personnel to improve CAT scores. CAT scores improved with police officers when training with the VirTra video system twice a week, for 4 consecutive weeks. These findings may eventually change training protocols across the nation for law enforcement officers. A video simulation system like VirTra system should be considered for assisting in improving anticipation timing in law enforcement officers or departments. Limitations of our study include the sample size, the lack of female officers available at the time, and the time of day (early morning) that was selected due to the availability of staff and personnel to run the video system at the police department.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-to-profit sectors. We would like to thank the Sarpy County Law Enforcement Center for the use of their police cadets.

"Sports Medicine Australia 2022 Conference" - Abstract Presentation

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.677

Examination of the Physical Education and Sports Teaching Department with SWOT Analysis: Student Opinions

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Type: Research Article (Received: 10.03.2023 – Accepted: 11.06.2023)

Abstract

This research aims to examine the Physical Education and Sports Teaching department through SWOT analysis and evaluate the present situation. The phenomenology design, one of the qualitative research methods, was used in the research. The research group consists of 56 Sports Science students, 29 females and 27 males. During the data collection phase, a semi-structured interview form created by the researchers was used, and the data obtained were analyzed using a descriptive analysis technique. As a result of the research, students described the Physical education and sports teaching department as sacred; they stated that the number of applied courses was small. They also emphasized that there is a diversity of work in the field and that injury is also a risk factor. According to the research results, it may be suggested to carry out complementary studies to improve the negative aspects and include other departments within the sports sciences.

Keywords: Physical Education, Opinion, Sport, Student, SWOT Analysis

Introduction

The concept of education is to help new generations integrate into society and improve their personality. As a process, it is defined as all the effects that change human behavior in a planned and programmed manner in line with certain goals (Başaran, 1994). According to Yeşilyaprak (2001), education is a process that enables the appropriate development of physical, sensory, cognitive, and social capabilities for the individual and society. In the context of these criteria, education aims to raise qualified people (Kızılkaya-Namlı & Temel, 2019; Kızıloluk, 2007; Darling-Hammond & Sykes, 2003). The prominent educational institutions for developing the skilled workforce in the world are described as colleges and universities (Aspfors & Eklund, 2017), and teacher training institutions in Turkey are located in higher education within the teaching department. Besides verbal and numerical ability in Turkey, one of the institutions that undertake the education of individuals with special talent is the Physical Education and Sports School or Sports Sciences Faculty, which is aimed at physical education and sports.

In the direction of the purpose of education systems, the mission of the Sports Sciences is to educate individuals with knowledge, healthy and high quality of life, with modern thinking in the development of physical education and sports by assimilating national and universal values (GÜSBF, 2021; AKÜSBF, 2021). The physical education and sports teaching departments' primary purpose are to train qualified physical education and sports teachers and academicians in line with the education systems (Karabulut, 2018). Therefore, this research is aimed to examine the profile of qualified educators in the field of physical education, where development and dissemination studies have been carried out from the past to the present (Öztürk-Kuter & Kuter, 2012; Karakuş & Küçük, 1999). In this sense, to evaluate the developmental dimensions of education, it is required to examine the individuals' opinions, the inputs and outputs of the process, and whether the goal is meeting.

In the literature, there are many national and international studies on the attitudes, perceptions, and opinions of physical education teachers towards the profession of students in physical education and sports (Aras & Asma, 2020; Deniz & Görgen, 2018; Bendíková & Nemček, 2017; Yildizer, Ozboke, Tascioglu & Yilmaz, 2017; Gutiérrez & Ruiz, 2009). It is seen that the studies carried out include information in terms of improving, popularizing, and accepting physical education and sports lessons in a cultural context and examining the attitudes of students. It can be stated that the common point of the studies is to adapt to the changing and developing world, to predict innovations, and to reveal existing thoughts. However, especially after the curriculum change, it is seen that the current studies, including the opinions about the department of physical education and sports teaching, are almost non-existent. In summary, it was found that attitudes towards the course and the profession were evaluated, but the departments' studies were limited within the framework of the curriculum and systematic structure. This research is expected to contribute to the field to meet students' interests and needs, train teachers, and improve the current situation. For this reason, this research aims to examine the Physical Education and Sports Teaching department through SWOT analysis and to evaluate the present situation.

Material and Method

Research Model

In the study, phenomenological design, one of the qualitative research methods, has been used. Phenomenology design tends to explore the experiences gained by the individual (Jasper, 1994); it is identified as a pattern that allows focusing on information that is aware but lacking detailed information (Yıldırım & Şimşek, 2013). In this study, the phenomenology design was chosen to understand and explain in-depth the perspectives and perceptions of students studying in physical education and sports teaching. Thereby, it is thought that it is essential to give direction to the next generation by revealing the views of individuals with experience.

Research Group

The research group consisted of 56 students, 29 females and 27 males, studying in a city of Afyon Kocatepe University Faculty of Sports Sciences situated in the Aegean region in Turkey. The students were selected voluntarily, through criterion sampling, among purposeful sampling methods.

Data Collection Tools

In the research, as data collection tools, "personal information form" and "semi-structured interview" forms were created by the researchers to reveal the opinions of the students about the department of physical education and sports teaching have used..

Before the semi-structured interview form was created, social media and written media statements were examined, and research questions were formed by taking expert opinions in this context. After taking expert opinions, a pilot study has conducted with 34 people. As a result of the pilot application, no changes have been made, and the sample size increased. There have four questions in the interview form. Interviews have recorded on a recording device with permission. Each interview lasted five minutes on average.

Data Analysis

The data were analyzed using the content analysis technique. Content analysis is accepted as an in-depth analysis technique with coding based on specific rules. This technique is aimed to reveal previously unknown themes, analyze and interpret the obtained data (Koca, 2017).

In the study, the data obtained from the participants through voice recording were written down. After verifying the written documents, the opinions of the 2 participants who were lacking were presented to the participants again, and they were completed. In the analysis of the data, the answers were first coded and divided into categories. The similarities and differences of the determined codes were determined, and the themes were tried to be formed by bringing together the codes related to each other. At this stage, three academicians' opinions were taken to ensure the validity and reliability of the measurement tool. In evaluating the data, frequency (f) and percentage (%) values were calculated.

Validity and Reliability

In order to ensure the validity of the research, permission was obtained from the participants to record the interviews. The data obtained in line with these permissions were transferred to the documents without any additions or deletions. Each participant was discussed separately.

In addition, the opinion of an expert other than the researchers was consulted for content analysis.

In terms of ensuring the Reliability of the research, the formula of Miles and Huberman (1994); The calculation was made using Reliability = Consensus / (Consensus + Disagreement). In addition, the principle that the consensus between the coders should be at least 80% and above was taken into account. As a result of the formulation calculation based on this information, it was noted that the Reliability of the research was achieved at a rate of 91%.

Findings

At this stage, the SWOT matrix was used to examine the research findings. In addition, the questions in the semi-structured interview form were handled and interpreted one by one.

Table 1. Students' opinions on the strengths of the department of physical education and sports teaching

Categories	**f**	**%**
Qualifying the teaching profession as sacred	11	18.3
The course of curriculum and contents to be well-equipped	8	13.3
Having information about sports branches	8	13.3
Increasing the quality of life	7	11.7
Raising of versatile sports trainers	4	6.7
Adequacy of facilities and materials	3	5
Excessive to be of employment area	3	5
Considering to physical education and sports course as the most popular course	3	5
Making learning permanent by combining education with entertainment	3	5
Possibility to be appointed to the state staff	2	3.3
Being able to communicate effectively get to academicians	2	3.3
Raising to healthy and conscious of athletes	2	3.3
Excessive to be the number of social activities	1	1.7
Gaining self-confidence	1	1.7
Possibility of double major	1	1.7
Assigning homework and projects that encourage research	1	1.7
Total	60	100

In Table 1, 16 categories have been determined in line with the students' opinions regarding the strengths of the Physical Education and Sports Teaching department.

Table 2. Students' opinions on the weaknesses of the department of physical education and sports teaching

Categories	**f**	**%**
The insufficient to be the number of applied courses	13	23.2
The department is qualified to worthless by society	12	21.4
Difficulty to be appointed to government staff and the limited number of quotas	10	17.8
Lack of specialization opportunity on a branch	6	10.7
Injuries encountered during the training process	5	9.0
Problems in the active participation of professional athletes in the education and training process	3	5.3
Problem and failure to focus on theoretical courses	2	3.6
Being disadvantageous in getting a coaching certificate	2	3.6

Negativities are experienced when sports are interrupted	1	1.8
Student profile that does not make an effort to research and develop	1	1.8
The insufficient to be the number of elective courses	1	1.8
Total	56	100

In Table 2, 11 categories have been determined in line with the students' opinions regarding the weaknesses of the Physical Education and Sports Teaching department.

Table 3. Students' opinions on the opportunities of the department of physical education and sports teaching

Categories	**f**	**%**
Diversity in business lines and job opportunities in the private sector	21	36.2
Raising to conscious athletes	11	19.0
Opportunity to gain experience by working in the field	7	12.1
Being equipped in terms of both sports and teaching profession	6	10.3
Performing the teaching profession in a healthy and social field	5	8.6
Encouraging students to develop through congresses, conferences, and seminars	4	6.9
Opportunity to receive training in sports branches from the experts of the field, and to learn a new branch	3	5.2
Opportunity to receive education in the same environment with individuals with different abilities	1	1.7
Total	58	100

In Table 3, 8 categories have been determined according to the students' opinions about the Department of Physical Education and Sports Teaching opportunity.

Table 4. Students' opinions of the department of physical education and sports teaching regarding threats and elements containing danger

Categories	f	%
Risk of injury	18	31.0
The anxiety of not being appointed to the state staff	15	25.9
The insufficient to be the number of employment	10	17.2
The obligation to tending to a different profession after graduation	8	13.8
Expressing an opinion that there is no situation seen as a danger or threat	3	5.2
Failure in applied courses and exams due to being injuries	3	5.2
Opportunity for individuals also who do not have a sports background to take advantage of the right to education	1	1.7
Total	58	100

In Table 4, 7 categories have been determined in line with the students' opinions about the Department of Physical Education and Sports Teaching threats and dangers.

Table 5. SWOT matrix for physical education and sports teaching department according to students' opinions

▪ Qualifying the teaching profession as sacred ▪ The course of curriculum and contents to be well-equipped ▪ Having information about sports branches ▪ Increasing the quality of life	▪ The insufficient to be the number of applied courses ▪ The department is qualified to worthless by society ▪ Difficulty to be appointed to government staff	**Internal Factors**

▪ Raising of versatile sports trainers ▪ Adequacy of facilities and materials ▪ Excessive to be of employment area ▪ Considering to physical education and sports course as the most popular course ▪ Making learning permanent by combining education with entertainment ▪ Possibility to be appointed to the state staff ▪ Being able to communicate effectively get to academicians ▪ Raising to healthy and conscious of athletes ▪ Excessive to be the number of social activities ▪ Gaining self-confidence ▪ Possibility of double major ▪ Assigning homework and projects that encourage research	and the limited number of quotas ▪ Lack of specialization opportunity on a branch ▪ Injuries encountered during the training process ▪ Problems in the active participation of professional athletes in the education and training process ▪ Problem and failure to focus on theoretical courses ▪ Being disadvantageous in getting a coaching certificate ▪ Negativities are experienced when sports are interrupted ▪ Student profile that does not make an effort to research and develop ▪ The insufficient to be the number of elective courses	
Strengths	**Weaknesses**	
Opportunities	**Threats**	
▪ Diversity in business lines and job opportunities in the private sector ▪ Raising to conscious athletes ▪ Opportunity to gain experience by working in the field ▪ Being equipped in terms of both sports and teaching profession ▪ Performing the teaching profession in a healthy and social field ▪ Encouraging students to develop through congresses, conferences, and seminars ▪ Opportunity to receive training in sports branches from the experts of the field, and to learn a new branch ▪ Opportunity to receive education in the same environment with individuals with different abilities	▪ Risk of injury ▪ The anxiety of not being appointed to the state staff ▪ The insufficient to be the number of employment ▪ The obligation to tending to a different profession after graduation ▪ Expressing a opinion that there is no situation seen as a danger or threat ▪ Failure in applied courses and exams due to being injuries ▪ Opportunity for individuals also who do not have a sports background to take advantage of the right to education	**External Factors**
Positive	**Negative**	

In table 5, there is a SWOT matrix that includes the opinions of the students participating in the research about the Physical Education and Sports Teaching Department. The findings finally, it has seen that the students present a opinions 16 on the strengths of the department, 11 on the weaknesses, 8 on the opportunities, and 7 on the threats. Also, the students' statements express their opinions about the department's strengths, weaknesses, opportunities, and threats. "Qualifying the teaching profession as sacred (n=11)", "The insufficient to be the number of applied courses (n=13)", "Diversity in business lines and job opportunities in the private sector (n=21)", and "Risk of injury (n=18)".

Discussion and Conclusion

This research aimed to investigate the students' opinions studying in the Department of Physical Education and Sports Teaching about the undergraduate program they are studying through SWOT analysis. In this context, the findings have obtained from the participants have tried to be discussed, interpreted, and supported with the current research findings in the literature.

When the opinions about the strengths of the department are examined, it has determined that the category of "Qualifying the teaching profession as sacred (f=11)" is the category where the most opinions are expressed, "Excessive to be the number of social activities (f=1)", "Gaining self-confidence (f=1)", "Possibility of double major (f=1)" and "Assigning homework and projects that encourage research (f=1)" are the categories in which the least opinions are expressed. Within the scope of this finding of the research, it is thought that the teaching profession's status due to social structure and cultural interactions affect students' opinions. In the research of Gültekin (2010), classroom teacher candidates saw the teaching profession more as a "sacred profession"; similarly, in the research of Aydın, Canavar and Akkın (2018), it has stated that the teaching profession is considered sacred, although the status level of teachers varies historically.

In another aspect, it can be stated that social acceptance, social environment, cultural, religious, and environmental factors are also factors in the formation of the opinion towards the teaching profession. As studies support this opinion (Bozbayındır, 2019), it has been determined that there are also studies that differ in the opposite direction. Reyes and Rios (2003) reported that although the teaching profession is accepted by society, developing information technologies and social platforms have the power to change this opinion. Ünsal (2018), in his study on this subject, has determined that the institutions and organizations that train teachers, the status of the teaching profession has decreased due to reasons such as the usual conditions of the day, policies, and economic conditions. In some studies, the effect of perceptions on the orientation to the teaching profession was mentioned from a divergent perspective, and they emphasized that altruism and intrinsic values could emerge as a factor (Bergmark, Lundström, Manderstedt & Palo, 2018; Balyer & Özcan, 2014).

When the opinions about the weaknesses of the department are examined, it has determined that the category of "The insufficient to be the number of applied courses (f=13)" is the category where the most opinions are expressed, "Negativities experienced when sports are interrupted (f=1)", "Student profile that does not make an effort to research and develop (f=1)," and "The insufficient to be the number of elective courses (f=1)," are the categories in which the least opinions are expressed. Their negative attitude towards theoretical courses can explain the reason for students' insufficient number of applied courses. Accordingly, the fact that students are more successful in applied courses than theoretical courses can be expressed as a factor. In the study of Kurtipek, Güngör, Esentürk, İlhan and Yenel (2020) too, it was stated that the students of the sports management department had an opinion on the low number of applied courses related to the department.

When the opinions about the opportunities of the department are examined, it is seen that the category of “Diversity in business lines and job opportunities in the private sector (f=21)” is the most commented, “Opportunity to receive education in the same environment with individuals with different abilities (f=1)” is the categories in which the least opinions are expressed. In this situation, individuals who graduate from the teaching department are teaching professions and coaching, sports expertise, etc. it can be explained by finding a job in professional groups. The development of technology and the emergence of e-sports as a need is thought to affect student opinions positively. In contrast to the results of this study, it is noteworthy that in the study conducted by Araç-Ilgar and Cihan (2019), students stated that job opportunities were limited in sports management and that they had difficulties in finding a job when they graduated.

When the opinions about the threats and dangers of the department are examined, it is seen that the category of “Risk of injury (f=18)” is the most commented, “Opportunity for individuals also who do not have a sports background to take advantage of the right to education (f=1)” is the categories in which the least opinions are expressed. These opinions can be explained by the negativities experienced by especially professional athletes in their professional lives. In the study of Özçakır and Sönmezoğlu (2017), it was concluded that there is a risk of injury among the problems faced by the sports students in the USA. Similarly, in the study of Videmšek, Karpljuk, Mlinar, Meško and Štihec (2010), it was determined that students studying at five different secondary schools in Slovenia were exposed to injury during class and in extracurricular activities. Also, it was reported that injuries occur mainly in the branch of athletics in physical education classes. In Austin, Rogers, and Reese (1980), in their study on high school students, it was stated that 5.4 percent of every 100 people were injured and applied to the school nurse.

In consequence of the research, the thought was formed that the Department of Physical Education and Sports Teaching students are committed to their profession and continue their teaching profession with pleasure rather than seeing it as a job. On the other hand, it can be said that they do not adopt and show interest in theoretical courses for pedagogical formation, that is, vocational education, based on the statement that they find the number of applied courses insufficient. According to their opinions on the department's opportunities, it can be thought that they consider gaining the teaching department as an advantage and feel safe. Based on this opinion, it can be stated that they are aware that they can get a job opportunity by obtaining certificates in other fields such as coaching and sports expertise. Besides, it was noteworthy that although they have favorable opinions depending on the profession, they perceive them as a psychological threat to the risk of physical injury.

In addition to the expressions that express the most opinions, the benefits of education can be mentioned in terms of increasing the quality of life, being open to improvement, being directed directly or indirectly, raising awareness, and gaining self-confidence in the context of other opinions. Within the scope of weaknesses, it can be stated that unrelated individuals who are far from the field have turned to the profession, their examination systems are not sufficient, talent should come to the fore, and professional athletes have problems. In terms of opportunities, the effects of comprehensive education on increasing professional quality and the importance of experience can be mentioned. Grigore, Moantă and Ghitescu (2016) also stated that the training platforms of performance athletes enrolled in higher education sports institutions are an opportunity to access, work and learn information. Finally, it can be emphasized that talent is not sufficient as a threat and danger factor, that verbal and physical abilities integrate and bring success and the existence of occupational anxiety dimension.

Recommendations

According to the research results, different perspectives can be considered to improve the positive aspects of the Department of Physical Education and Sports Teaching with the present situation recorded as in consequence of the study. Complementary studies may be recommended to improve the negative aspects. It may be suggested to conduct a study involving physical education teachers, other departments related to Sports Sciences such as Coach Training and Recreation. Also, the 800 thousand thresholds determined for the examination system placement scores can be addressed to variables such as formation.

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.678

Examining of Students' Failure Perceptions in Sport Sciences Faculty

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Type: Research Article (Received: 02.03.2023 – Accepted: 05.06.2023)

Abstract

The purpose of this study was to examine the students' failure perceptions in Faculty of Sport Sciences. In the study descriptive and survey method was used to determine the existing situation. The sample group of the study consisted of 400 university students (161 male, 239 female). As a data collection tool, Performance Failure Appraisal Inventory (PFAI) and personal data form were used in the study. In statistical analyzes; descriptive statistical analyzes, normality test, t-test and Anova tests were performed for defining test results' significantly differed or not with various variables. As a result, it was determined that the students' fear of failure scores are under average level (mean=-4,5225) and their test results were significantly differed according to their gender and age variables.

Keywords: Sport, Student, Failure, Perception

Introduction

Success or failures are two important phenomena encountered in all areas of life. About the success of individuals who have reached university age, the first thing that comes to mind is academic success (Yılmaz, 2018). Failure means not being able to fulfill a task and not getting success from that task. Those who perform above the determined level in physical activities are considered successful, and those who perform below the determined level are considered failure (Ülgen, 1997). The perception of success should not be limited to academic success only. Performing at a high level in physical activities is also a success. Achieving these gains completely is considered success, and incomplete learning is considered a failure (İçdi, 2020). All of the experiences, education and personal characteristics of students at an early age can affect the results of their choices in the future (Ergül, 2017). Looking at the past lives of people who have come to important positions today, it is seen that they climb the ladder of success with confident steps. It could also mean that they avoid failure.

The reasons for an individual's failure can be psychological, physical or social (Kağan, 2006). If there is a failure situation, it is necessary to consider this situation as a whole instead of seeing it as a problem. Otherwise, if the situation turns into a problem and this problem is blamed only on the individual, mutual dedication, support and trust will be lost, communication will be damaged and worse situations will arise (Yaşar et al., 2004). There are many types of fear developed against living beings or inanimate things. There are many people who have fear of the dark, heights, various sounds or any kind of animal etc. Fear of failure is one of them. While success is a goal that many people want to reach, there are many individuals who have fear of success (İçdi, 2020). Fear is a negative emotion that a person develops against an event or object as a result of his/her bad experiences (Güler, 2004). The motive to avoid failure is considered a disposition to avoid failure and/or a capacity for experiencing shame and humiliation as a consequence of failure (Atkinson, 1957). Fear of failure brings with it negative consequences both in academic life and in sports competitions. As a result of the fear of failure, the individual experiences both performance anxiety and shame (Conroy, 2001). People who experience the fear of failure in high doses naturally have a feeling of inadequacy and tend to avoid bad consequences (Elliot et al., 1997).

When athletes perceive that their demands (to win, perform well, etc.) will not be met, they are likely to feel that their goals are under threat. The perception of being unable to meet will jeopardize their chances of achieving their desired goals. It is possible that they perceive failure as a threat and fear such failure (Sagar et al., 2009). The success and failure of a performance can be attributed to various factors. For example, the success of a person who finished first in a swimming race can be attributed to; ability (a stable factor) or luck (an unstable factor), high effort in the last 50 meters (an internal reason), or an unfamiliar course as a competitor (an external cause), race plan (a factor you can control), or opponent's physical condition (an uncontrollable factor). Or, the failure of a performance can be attributed to leaving the training program, due to lack of talent (a stable factor) or a bad coach (an unstable factor), a bad background (an internal cause), or the training facility being far from home (an external cause) or a lack of effort (a factor that can be controlled) or the cost of the training program (a factor outside of control) etc. (Weinberg et al., 1995).

Achievement motives and competence perceptions are viewed as distinct, independent constructs that account for unique variance in the adoption of achievement goals. Like achievement motives, competence perceptions are presumed to orient individuals toward success or failure and are posited to have an indirect influence on achievement behavior through their effect on achievement goal adoption (Elliot, 1999). On the other hand, the person in whom the motive to avoid failure is stronger should select either the easiest of the alternatives or should be extremely speculative and set his goal where there is virtually no chance for success (Atkinson, 1957). Every individual wants to be successful. However, the evaluation of individuals according to established standards inevitably causes them to be compared with others and to be described as successful or unsuccessful (Yörük, 2007).

It is necessary to know that minimizing this fear is as a natural process for being successful, and that every failure is an experience and a kind of achievement for the individuals. It is a sadly situation for the society that the unsuccessful individual is lost in the sense of failure. It is necessary to raise awareness that every success opens a new door, and every failure will open new doors in different ways. In the light of all this information, the aim of the present study is to examine the perception of failure of the students studying at the Faculty of Sport Sciences.

Material and Method

In the research, a descriptive survey method was used to expose the current situation. Descriptive research is the first and basic research activity. These studies have great importance in understanding and increasing knowledge. Most of the education problems are descriptive (Balcı, 1997). Survey models are a research approach that aims to describe a past or present situation as it is (Karasar, 2009). The study consisted of two phases, theoretical and practical. In the first stage, the literature on the subject was reviewed and the results of previous research were examined. By examining the information obtained, a detailed theoretical framework on the subject was prepared in terms of variables. In the second stage, data were collected from the participants in the light of this theoretical framework.

Research Group

In survey research, a sample is selected from the universe for descriptive research and the data collection process is based on the answers given to the questions posed to the sample (Büyüköztürk et al., 2008). The research group of the study consists of 400 individuals (239 females and 161 males) who are students of Physical Education Teaching, Coaching Education, Sports Management and Recreation Departments in Bartın University Faculty of Sports Sciences (in the fall of 2022-2023). In the study, “stratified sampling” was used. In this sampling, some populations can be subdivided into subgroups, known as strata (one is called a stratum). Stratified sampling involves strategically selecting participants from each subgroup. It was also select equal-sized (nonproportional) samples from subgroups for subgroup comparisons (Gay et al., 2011). So, equally 100 students from each department of the faculty were participated to the study.

Instrument

The questionnaire form which was created to examine the perception of failure of individuals studying at the Faculty of Sport Sciences, consists of two parts. In the first part of the data collection tool, there are personal questions directed to collect information about individuals. These are questions about gender, age, department, sports and year of sport experience. In the second part of the questionnaire, "Performance Failure Evaluation Inventory" developed by

Conroy et al. (2002) and adapted into Turkish by Engür (2013) was applied. “Performance Failure Evaluation Inventory” consists of 5 sub-dimensions and 25 items in a 5-point Likert type (-2 I do not believe at all, +2 I believe 100% of the time). These 5 subscales named as; “fear of experiencing shame and embarrassment”, “fear of lowering one’s self-esteem”, “fear of an uncertain future”, “fear of losing interest in important people” and “fear of disappointing important people”. High scores indicate an advanced fear of failure.

Data Collecting

Required permissions were obtained for the application of the data collection tools. And the questionnaires were applied to the individuals in their free times. Individuals were also verbally informed about filling of the data collection tools. Before starting the survey, consent form was obtained from the participants. The questionnaire was prepared digitally with Google Form® and the participants were asked to fill it in face-to-face during the 2022-2023 fall semester through various applications such as WhatsApp and QR Code during breaks between the lessons. Then, the answers obtained were transferred to the statistical analysis program in the computer by the researchers.

Analysis of Data

As a statistical method in the evaluation of the data in the research; frequency, normality test, t-test for independent groups and one-way analysis of variance (ANOVA) for independent groups were used. Additionally, in one-way analysis of variance (ANOVA) test, LSD post hoc test was performed to find out the differences between the groups. The level of significance in the analyzes was taken as $p<0.05$.

Findings

As a result of the analyzes carried out to examine the perception of failure of the individuals studying at the Faculty of Sport Sciences in terms of various variables, it was determined that the perception of failure of the individuals was below the average (mean=-4.5225).

It was determined that the scores of the participants from the scale differed significantly according to the gender variable. In Table 1, the analysis results between the "gender" and "perception of failure" are given.

Table 1. T-test results of gender variable and perception of failure

	Gender	N	$\overline{X}$	Sd	t	P
Factor 3	Male	239	-,47	3,60	-2,05	,041
	Female	161	,25	3,33		
Factor 4	Male	239	-2,11	5,37	2,173	,030
	Female	161	-3,32	5,65		

$p<0,05$

According to Table 1, the scores of the individuals participating in the study, the sub-factors of the scale; Factor 3 (fear of the uncertain future) and Factor 4 (fear of losing the interest of important people) showed a significant difference according to gender. The Anova test results of individuals' "age" variable and the "perception of failures" are given in Table 2.

Table 2. Anova results of age variable and perception of failure

		Sum of Squares	df	Mean Square	F	p	Post Hoc (LSD)
Factor 2	Between groups	103,138	2	51,569	3,476	,032	2-1
	Within groups	5889,639	397	14,835			
	Total	5992,778	399				
Factor 3	Between groups	131,998	2	65,999	5,461	,005	2-1 3-1
	Within groups	4797,679	397	12,085			
	Total	4929,678	399				
Factor 4	Between groups	233,547	2	16,774	3,894	,021	2-1
	Within groups	11906,250	397	29,991			
	Total	12139,798	399				
Factor 5	Between groups	193,891	2	96,946	5,134	,006	2-1
	Within groups	7495,986	397	18,882			
	Total	7689,877	399				
Total	Between groups	4365,276	2	2182,638	5,186	,006	2-1
	Within groups	167074,522	397	420,843			
	Total	171439,798	399				

p<0,05 **Group 1:** 17-19, **Group 2:** 20-22, **Group 3:** 23 and up

According to Table 2; there are significantly differences between the age variable of individuals and the sub-factors and total score of the scale; Factor 2 (fear of reducing someone's self-esteem), Factor 3 (fear of the uncertain future), Factor 4 (fear of losing the interest of important people) and Factor 5 (fear of disappointing important people).

Discussion and Conclusion

The scores of the individuals participating in the study differed significantly on Factor 3 (fear of the uncertain future) and Factor 4 (fear of losing the interest of important people) according to gender. Elison and Patridge (2012), found a significant difference in the sub-dimensions of Factor 1 (fear of experiencing shame and embarrassment) and Factor 2 (fear of reducing one's self-judgment) according to gender in their study on university athletes. Sagar and Jowett (2012), found a significant difference in the Factor 2 (fear of reducing one's self-esteem) sub-dimension in individuals according to gender in their study on British athletes. Kahraman and Sungur (2016), in their study to secondary school students' fear of failure, found a significant difference in Factor 1 (fear of experiencing embarrassment and embarrassment) and Factor 4 (fear of losing the interest of important people) sub-dimensions between girls and boys. Correia et al. (2017), found a significant difference in the sub-dimensions of Factor 1 (fear of experiencing embarrassment and embarrassment), Factor 2 (fear of diminishing one's self-esteem), and Factor 3 (fear of the uncertain future), while they did not find a significant difference in the general fear of failure according to gender in the study they conducted with the athletes. Amiryan et al. (2018), in their study on athletes, found statistically significant difference between Factor 5 (fear of disappointing important people) and gender. André and

Metzler (2011), found significant differences between gender and general fear of failure in their study. Şeker (2017), found a significant difference in Factor 1 (fear of experiencing shame and embarrassment) and Factor 3 (fear of the uncertain future) sub-dimensions according to gender in his study on elite athletes. Gómez-López et al. (2019), found a significant difference in Factor 4 (fear of losing the interest of important people) sub-dimensions according to gender in their study on handball players. Alp (2020), in his study to the Turkish Taekwondo national team, found a significant difference in the general fear of failure and Factor 3 (fear of the uncertain future) sub-dimensions according to the gender variable. These results are consistent with the current study. On the other hand, Caraway et al. (2003), Yörük (2007), Özdiyar (2008), Conroy et al. (2009), Sagar et al. (2011), Cankurtaran (2021), found that there was no significant difference according to gender in terms of fear of failure. These studies' results not consistent with the current study.

It was determined that the scores of the individuals participating in the current study from the scale showed a significant difference according to age variable and general fear of failure and 4 sub-factors except for Factor 1 (fear of experiencing shame and embarrassment). Westenberg et al. (2004), found a negative significant correlation between age and fear of failure in their study with athletes. Hazari and Pathak (2016) found that young 'Mallakhamb' players at the national level have a greater fear of failure than the older age group. Şeker (2017), found a significant difference in Factor 1 (fear of experiencing embarrassment and embarrassment) and Factor 3 (fear of the uncertain future) sub-dimensions according to the age of individuals in his study on elite athletes. Subaşı (2019), found that there was a significant difference between age and Factor 1 (fear of experiencing embarrassment and embarrassment) and Factor 3 (fear of the uncertain future) sub-dimensions' scores of adolescents. Also, Cankurtaran (2021), found a statistically negative and moderately significant relationship between adult athletes' fear of performance failure and their age variable. These results are consistent with the current study.

As a result, it was determined that the students' perception of failure is below the average and the scale scores of the students were significantly differed according to their "gender" and "age" variables. The fact that the study group consists of only one university is seen as a limitation. In future studies, it can be suggested to increase the number of subjects by including the subjects studying in other Faculties of Sport Sciences from different universities.

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.679

Investigation Of The Effect Of Wrestling Course In Terms Of Different Parameters For Law Enforcement Defense And Intervention Techniques Course, Which is A Defense Sport Of The Gendarmerie

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Type: Research Article (Received: 29.01.2023 – Accepted: 12.06.2023)

Abstract

The aim of this study is to examine the situational interest and perceived competence of the Gendarmerie and Coast Guard Academy students who are taking wrestling courses for the Law Enforcement Defense and Intervention Techniques (KSMT) course, which is the defense sport of the Gendarmerie. In the Law Enforcement Defense and Intervention Techniques (KSMT) course, it is aimed to intervene with the least harm and the least damage to the ability of the gendarmerie personnel to regulate their behavior while intervening in any difficulty they encounter during their duties. Law Enforcement Defense and Intervention Techniques (KSMT) is a nerve pressure based technique that does not require more force. In the study, semi-experimental design method with pre- and post-test control groups, which is one of the experimental design methods, was applied. 80 faculty students of the 4th grade who took KSMT course after taking Wrestling courses at Gendarmerie and Coast Guard Academy in 2021-2022 participated in the study as an experimental group, and 80 Officer Training Center Students who took KSMT courses without taking Wrestling lessons participated as control groups. As a result of the study, it is seen that the experimental (Faculty) and control (SUEM) groups participating in the research had a significant difference ($p<0.05$) in their situational interest and perceived proficiency level for the course in the final test. According to the result, it is seen that the experimental group students who take wrestling lessons have a higher level of perceived proficiency than the students in the control group.

Keywords: Self Defence, Sport, Wrestling

Introduction

Law Enforcement Defense and Intervention Techniques, which is the defense sport of the gendarmerie, during the duty of the gendarmerie personnel; are the defense and intervention methods applied in order to neutralize suspicious persons and persons who threaten security and public order and to establish public order (Öztürk, 2022). The most important principle in CSR is to ensure balance and proportionality by intervening within legal limits. The target in KSMT; is the ability of personnel to develop strategies of proportional intervention techniques by detecting danger signals (JSGA, 2008; Ozturk, 2022).

The purpose of the KSMT training is to run to the demand of the citizens who suffer the least damage and the least damage while performing the duties of the gendarmerie personnel and to eliminate their grievances. In addition, it is aimed to intervene in suspicious persons in accordance with the law and the principle of proportionality by using defense techniques based on nervous pressure while performing their duties.

Wrestling is a sport in which two athletes try to control their opponent and establish superiority by using some motoric characteristics without any equipment on the mat of predetermined dimensions (Aydos et al., 2009; Bayraktar, 2011). Wrestling KSMT provides the infrastructure for holding sprain and throw distance, getting rid of hugs. Gendarmerie and Coast Guard Academy Faculty students are given 2 semesters of wrestling courses in the faculty preparatory class in order to provide an infrastructure for the KSMT course.

In Law Enforcement Defense and Response Techniques, it is vital that law enforcement personnel are careful when performing their duties and are able to plan what they can do. The behaviors that will be necessary for the law enforcement personnel to organize positive or negative situations are related to the competence that the person perceives (Bandura, 1997). The person's attention and reaction to the event during the event is related to situational attention (Hidi, 2001).

The aim of this study is to examine the effect of Gendarmerie and Coast Guard Academy students taking wrestling courses on the Gendarmerie's defense sport of Law Enforcement Defense and Intervention Techniques (KSMT) in terms of situational interest and perceived competence

Methods

In the study, semi-experimental design method with pre- and post-test control groups,which is one of the experimental design methods, was applied. This method aims to find the cause and effect relationship between variables (Büyüköztürk, 2008). The aim of this study is to examine the effect of the wrestling course on the Gendarmerie and Coast Guard Academy Students in terms of different parameters for the Gendarmerie Defense Sports Law Enforcement Defense and Intervention Techniques (KSMT) course. While the universe of this study consists of 600 faculty students studying in the gendarmerie and coast guard academy, the sample group consists of 4 classes of 80 faculty students selected by unbiased method.

80 faculty students of the 4th grade who took KSMT courses after taking wrestling lessons at the Gendarmerie and Coast Guard Academy in 2021-2022 participated in the study as an experimental group, and 80 Officer Training Center Students who took KSMT courses without kickboxing lessons participated as control groups.

The students in the experimental group were taught 28 hours of Wrestling lessons per week for 14 weeks before taking the KSMT lesson, while the KSMT subjects were taught to both groups for a total of 28 lessons from 2 hours per week for 14 weeks. Both groups were given pre-test situational perception and perceived competence testing before starting the study. After the study was completed, both groups were given the final test situational perception and perceived competence test.

Situational Interest Scale: Scale; Developed by Rotgans and Schmidt (2011a), Doğru and Eren (2016), Adapted to Turkish by. Both versions of the measuring instrument consist of 6 items of 5 Likert type. Both versions have a single-factor structure. Items are scored in the range of "1- Absolutely not right for me" to "5- Absolutely right for me". The Cronbach Alpha internal consistency coefficient of the measurement tool was calculated as .94, (Doğru and Eren, 2016).

Perceived Competence Scale: The scale is single sub-dimensional and consists of 4 items. Scaleto measure the participants' self-perceived competence for the physical education courseUsed. Scale Williams and Deci (1996) and Williams, Freedman and Deci (1998) has been used in studies in the field of medicine. The cronbach alpha value of the scale is 0.80has been found on.

Table 1. Descriptive Statistics on Students

	n	%
Experiment (Faculty)	80	50
Control (SUEM)	80	50
Sum	160	100

When we look at Table 1, the experimental group consists of 80 Gendarmerie faculty students and the control group consists of 80 Subey education center students. A total of 160 students participated in the study.

Table 2. Wrestling Course Subject Distribution Given to Faculty Students

Week	Topics
1.Subject	Theoretical: International Wrestling rules Practice: Arm pulling and pressing combinations, roll the log on the ground technique
2. Subject	Bridge work
3. Subject	Armpit crossing and pressing, auger and trap technique applications on the ground
4. Subject	Single-double diving, ground flapping techniques
5. Subject	Bravle technique-Arm pulling
6. Subject	Danab and German clesia techniquesSkull technique: turning and shooting stages in the airReverse winding, winding technique

Looking at Table 2, wrestling lesson topics are included.

Table 3. Law enforcement defense and Intervention Techniques course Topic

Week	**Topics**
1. week	KSMT Entrance
2. week	Hold-Buckle-Throw Distance
3. week	Kick Distance and Blocks
4. week	Front Intervention Techniques

5. week	Rear Intervention Techniques
6. week	Techniques to Intervene in Overwhelming Instruments
7. week	Intervention Techniques for Piercing-Cutting Tools
8. week	Getting Rid of Hugs
9. week	360 Degree Person Control Techniques
10. week	Techniques for Using Baton
11. week	Techniques for Using Baton
12. week	Side Intervention Techniques
13. week	Handcuff and Top Search Techniques
14. week	Person Handling Techniques

When we look at Table 3, KSMT Course topics are included. KSMT consists of 14 weeks of coursework.

Findings

	Groups	N	X	Ss	t	p
Situational Perception Final Test	Faculty	80	88,12	1,582	,020	,984
	SUEM(Trainees)	80	88,07	2,017		

Table 4. Situational Perception Pretest Independent Samples t-Test Results

As a result of the examination, it is seen that there was no significant difference between the situational perception levels of the experimental (Faculty) and control (SUEM) groups participating in the research in the final test (p>0.05).

	Groups	N	X	Ss	t	p
Situational Perception Final Test	Faculty	80	3,53	,468	2,517	,013
	SUEM(Trainees)	80	3,38	,273		

Table 5. Situational Perception Final Test Independent Samples t-Test Results

As a result of the examination, it is seen that there is a significant difference between the motivation levels of the experimental (faculty) and control (SUEM) groups participating in the research for the course in the last test (p<0.05) and the motivation level of the faculty, which is the experimental group, for the course is higher.

Table 6. Perceived Proficiency Pretest Independent Samples t-Test Results

	Groups	N	X	Ss	t	p
Perceived Indigenousness	Faculty	80	25,11	,652	-,502	,612
	SUEM(Trainees)	80	25,56	,615		

As a result of the examination, it is seen that there is no significant difference between the level of competence perceived in the final test of the test (faculty) and control (SUEM) groups participating in the research (p>0.05).

Table 7. Detected Locality Final Test Independent Samples t-Test Results

	groups	N	X	Ss	t	p
Perceived Indigenousness	Faculty	80	26,87	,330	2,12	,035
	SUEM(Trainees)	80	25,41	,603		

As a result of the examination, it is seen that there is a significant difference between the situational perception levels of the experimental (faculty) and control (SUEM) groups participating in the research for the course in the last test ($p<0.05$) and the perceived proficiency level of the faculty, which is the experimental group, is higher.

Discussion and Conclusion

As a result of the study, the participants in the experimental group participating in the research had a statistically significant increase in the levels of situational perception between the pretest and the posttest, and there was no statistically significant difference in the levels of situational perception and perceived competence between the pretest and post-tests of the participants in the control group participating in the research ($p> 0.05$).

As a result of the study, it is seen that there is a significant difference ($p<0.05$) between the final situational perception levels of the experimental (Faculty) and control (SUEM) groups participating in the research. According to the result, it is seen that the experimental group students who take wrestling lessons have a higher level of situational perception and perceived competence than the students in the control group. In this case, it can be said that the wrestling course increases the level of situational perception and perceived competence against the course of Law Enforcement Defense and Intervention Techniques, which is the defense sport of the Gendarmerie. Since this situation gives certain characteristics such as strength and agility of the wrestling course, it can be thought that the Gendarmerie increases the situational perception and perceived proficiency levels against the Law Enforcement Defense and Intervention Techniques course, which is a defense sport. It is seen that these results are in line with the results obtained with similar studies (Yıldırım and Kocaekşi, 2020; Lightning 2013; Forward, 2019; Ekinci, 2014; Güvendi et al.2018).

Fairclough (2003), high school physical educationIn her courses, she examined the relationship between physical activity, perceived competence and fun.According to the findings, a moderately significant relationship was found between perceived competence and entertainmentare.

Suggestions

1. In this research, the subject of CSM is discussed in the students who take wrestling course and the effect of other defense sports on the KSMT course can be examined.

2. This research was conducted on JSGA faculty and SUEM students. Similar work can be planned at other schools in the JSGA and at the National Defense University and the Police Academy.

3. It is recommended to investigate the effect of different variables on CSCT course.

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.680

Investigation of the Effects of Morphological Structure of the Foot and Ankle Flexibility in Folk Dancers on Foot and Ankle Disorders

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Type: Research Article (Received: 18.11.2022 – Accepted: 30.03.2023)

Abstract

This study was conducted to investigate the relationship of morphological structure of foot, and ankle flexibility to foot and ankle disorders in folk dancers. 42 dancers participated in the study. The morphological structures of feet were determined by using footprint analysis method with 4 parameters and ankle flexibility properties were determined by using 4 parameters. Expanded nordic musculoskeletal questionnaire was used to determine foot and ankle disorders. The data were evaluated with Spearman Correlation and Man-Whitney U tests at $p < 0.05$ significance level. When the foot and ankle parameters of unhealthy and healthy volunteers were compared, a statistically significant difference was found between the two groups in the ChippauxSmirak index (CSI), Staheli index (SI) and dorsiflexion (DF°) values in the right foot, and in the CSI and SI values in the left foot. When the relationship of foot and ankle parameters to pain severity and pain frequency in unhealthy volunteers was examined, it was observed that there was a negative correlation between DF° and eversion (E°) values and pain frequency, and between DF°, PF° and E° values and pain severity in the right foot. In the left foot, a negative correlation was found between the DF° values and the frequency of pain. ($p<0,05$). In this study, some components of the foot morphological structure and ankle flexibility properties were found to have a relationship with foot and ankle disorders. These results can be taken into account in the determination of risk factors and preventive measures in terms of pain, injury and various disorders in the foot and ankle region.

Keywords: Folk Dancers, Foot Morphology, Ankle Flexibility, Foot and Ankle Disorders

Introduction

Dance is a unique combination of art and athletics, while dancers are artistic athletes (Hald, 1992; O'Loughlin et al., 2008). In dance, as in sports, any figure takes place in the human body through intense movements of a collection of interconnected solid segments (Wilson and Kwon, 2008). This intense mobility demands extreme physical demands. For these reasons, the extreme positions that occur while the dancers are performing the figures can cause injuries to the feet and ankles (Kadel, 2006; Rickman et al., 2012).

The foot and ankle are structures that must be understood in the context of dance. It is known that the morphological structure of the foot, which is the end point and the part of the locomotor chain that comes into contact with the ground, is important in activities such as walking and running. Due to this locomotive structure and morphological characteristics of the foot, it allows the performance and stability to be maintained in the athletic art of dance (Kidder et al., 1996; Ledoux et al., 2003; Russell et al., 2008). The ankle joint, on the other hand, is an important component of the normal gait cycle in order for its dynamic and static stabilizers to maintain their structural integrity. From the point of view of the dance world, the ankle becomes even more important given the range of motion and stress applied to the ankle during various dance routines (O'Loughlin et al., 2008).

Dancing is not dangerous, but dancers suffer injuries when the limits are pushed. Foot and ankle injuries constitute the majority of dancers' injuries. Dancers often have to work with pain and injuries in the feet and ankles. For these reasons, it is important to understand the mechanism of injury and its factors beforehand (Macintrye and Joy, 2000; Özkan et al., 2013; Markula, 2015).

Therefore, both in the training sessions combining the development of conditional abilities and technical-tactical elements and demonstrations, it is concluded that the morphological structure of the foot and the flexibility of the ankle are important especially in terms of foot and ankle injuries that may occur due to various reasons.

In this context, in this study, it is aimed to investigate the relationship of morphological structure of foot, and ankle flexibility to foot and ankle disorders in folk dancers. This research is important in terms of determining the relationship between structural changes in the anatomical components of the foot and ankle in dancers, and foot and ankle injuries.

Material and Method

Study Method

This study is descriptive research conducted to investigate the relationship of morphological structure of foot, and ankle flexibility to foot and ankle disorders in folk dancers.

Study Group

42 male students with a mean age of 21.73 ± 2.57 years who are studying at Giresun University State Conservatory Folk Dance Department voluntarily participated in the study. The research was carried out in accordance with the Declaration of Helsinki, with the date and decision number 03.10.2019/14 of Giresun University Faculty of Medicine Ethics Committee.

Data Collection Tools

Determination of Morphological Structure of Foot

Footprint analysis method obtained from the foot plantar pressure was used to determine the foot morphology (Stavlas et al., 2005). The relevant researchers recommend that multiple parameters should be used when evaluating the foot type (Chuckpaiwong et al., 2009). In this study, footprint measurement was performed by footprint metric analysis method using 4 morphometric parameters in order to evaluate foot structure. The footprint method, which measures the sole pressure of the foot, is a very good way of understanding where the load is coming from and which tissues are under extreme mechanical stress (Bek, 2018). Chinesport brand podoscope was used for footprint measurements.

Footprint Measurement and Parameters

Foot plantar pressure images of all volunteers were taken from the podoscope by using a camera in the footprint analysis. Morphometric measurements were made on the images and cm was used as the metric unit. The application was made for both feet as right and left.

Parameters

Foot Index (FI): Obtained by dividing the transverse breadth of the foot by longitudinal length and multiplied by 100. FI=(FB/FL)*100(Moudgil et al., 2008).

Chippaux-Smirak Index (CSI): It is the ratio of the minimum width of the middle arch area of the foot (B) to the maximum width of the metatarsal region (C). CSI=(B/C)*100. (Stavlas et al., 2005).

Staheli Index (SI): It is the ratio of the minimum width of the middle arch area of the foot (B) to the maximum width of the posterior region of the foot (A). SI=B/A (Staheli et al., 1987).

Clark Angle (C°): It is the angle between the line connecting the most medial metatarsal point and the most medial heel region and the line connecting the inner medial arch point (concavity of the arch) and the most medial metatarsal point (Razeghi and Batt, 2002).

Fig 1. Foot İndex

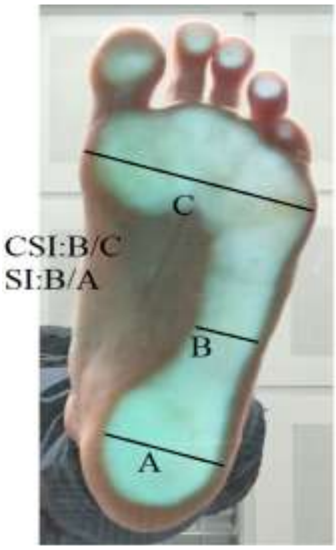

Fig 2. CSI and SI

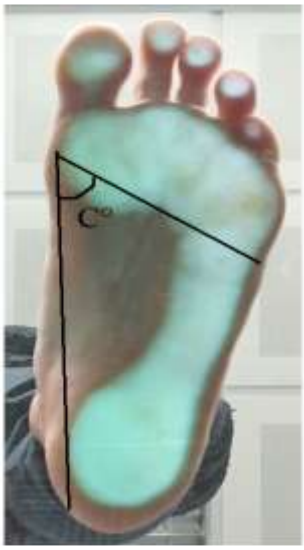

Fig 3. C°

Joint Range of Motion Measurement and Parameters

The use of a goniometer has been recommended as an objective measurement method in the determination of joint range of motion. (Menadue et al., 2006). The ankle joint range of motion of the participants were measured in 4 parameters with a Baseline brand 20 cm goniometer.

Dorsiflexion (DF°) and Plantar flexion (PF°): While the volunteer was in supine position, the pivot point of the goniometer was placed in the lateral malleolus. The fixed arm was kept parallel to the lateral midline of the fibula. The movable arm was placed parallel to the lateral midline of the 5th metatarsal bone, and dorsiflexion and plantar flexion measurements were performed (Otman and Köse, 2014).

Inversion (I°) and Eversion (E°): The volunteer was placed in a sitting position at 90 ° with the legs suspended from the knee. The pivot point of the goniometer was placed on the anterior face at the midpoint of the ankle between the malleolar. The inversion and eversion movement angles were measured by placing the fixed arm towards the anterior midline of the leg towards the tuberositas tibia and the movable arm towards the midline of the second metatarsal (Otman and Köse, 2014).

Determination of Foot and Ankle Disorders

Expanded nordic musculoskeletal questionnaire was used to determine foot and ankle disorders of volunteers (Dawson et al., 2009).As a result of the questionnaire, two groups of unhealthy volunteers (n: 21) and healthy volunteers (n: 21) were determined according to the yes-no answer to the question “Have you experienced any foot and ankle disorders in the last 12 months?”. The volunteers who answered Yes were divided into two subgroups according to the disorder of both feet or right foot (n: 21) and both feet or left foot (n: 21). According to the questionnaire, in order to determine the frequency of pain experienced in the groups with disorder, they were asked to choose one of the options continuously, occasionally and rarely, and these options were quantitated with 3, 2 and 1 respectively. The severity of the pain, as indicated in the questionnaire, was asked to indicate the pain experienced by a number between 1 and 10. Foot and ankle parameters of unhealthy and healthy volunteers were compared separately for right and left feet. Bilateral asymmetry between foot and ankle parameters was investigated in unhealthy volunteers. The relationship between the frequency and severity of pain and the selected parameters of the painful foot and ankle was examined.

Data Analysis

Statistical analysis was performed using SPSS package program. Shapiro Wilk test was used to test the normality of the data.Since the data were not normally distributed, the Mann-Whitney u test (table 1, table 3) was used to determine the difference between the parameters, and the spearman correlation test was used to determine the relationship between the parameters (table 2). Results were evaluated at p <0.05 significance level.

Findings

Table 1. Differences between foot and ankle parameters of unhealthy (n:21) and healthy (n:21) volunteers

Parameters	Right foot and ankle (Mean±Sd)			Left foot and ankle (Mean±Sd)		
	Unhealthy volunteers	Healthy volunteers	P value	Unhealthy volunteers	Healthy volunteers	P value
FI	38,46±2,05	37,95±1,82	0,753	38,80±1,60	38,42±1,76	0,365
CSI	34,40±6,62	28,37±8,4	**0,021***	34,97±6,30	28,09±8,36	**0,038***
SI	60,44±10,07	48,64±12,65	**0,003***	60,99±9,85	49,44±13,99	**0,016***
C°	48,71±8,63	51,33±14,33	0,399	49,43±9,68	48,00±12,54	0,70
DF°	13,09±10,04	19,71±7,97	**0,038***	14,52±9,26	14,80±6,21	0,970
PF°	64,76±6,82	66,47±5,43	0,340	63,57±7,85	67,57±6,85	0,078
I°	35,76±7,23	33,73±11,67	0,240	36,04±10,33	37,71±6,49	0,219
E°	23,90±12,46	23,38±12,78	0,960	19,48±13,41	20,40±6,65	0,160

Mann-Whitney U test (p<0,05). FI:Foot Index; CSI: Chippaux-Smirak Index; SI: Staheli Index; C°:Clark Angle; DF°:Dorsiflexion; PF°:Plantar Flexion; I°:Inversion; E°:Eversion.

When the foot and ankle parameters of unhealthy and healthy volunteers were compared, a statistically significant difference was found between the two groups in the CSI, SI and DF° values in the right foot, and in the CSI and SI values in the left foot. (p<0,05,Table 1).

Table 2. The relationship between the frequency and severity of pain and the selected parameters of the painful foot and ankle

Parameters			FI	CSI	SI	C°	DF°	PF°	I°	E°
Right foot (n:21)	**Pain frequency**	**r**	0,321	-0,294	-0,360	0,234	**-0,509***	-0,376	0,025	**-0,461***
		p	0,156	0,196	0,109	0,307	**0,018**	0,093	0,915	**0,036**
	Pain severity	**r**	0,308	-0,384	-0,361	0,170	**-0,447***	**-0,659****	-0,287	**-0,559****
		p	0,174	0,086	0,108	0,461	**0,042**	**0,001**	0,206	**0,008**
Left foot (n:21)	**Pain frequency**	**r**	-0,020	-0,157	-0,116	0,055	**-0,527***	-0,329	-0,216	-0,267
		p	0,930	0,497	0,616	0,814	**0,014**	0,146	0,346	0,241
	Pain severity	**r**	0,051	-0,305	-0,058	0,251	-0,403	-0,308	-0,337	-0,324
		p	0,828	0,178	0,803	0,272	0,070	0,174	0,136	0,152

Spearman correlation test (p<0,05). FI:Foot Index; CSI: Chippaux-Smirak Index; SI: Staheli Index; C°:Clark Angle; DF°:Dorsiflexion; PF°:Plantar Flexion;I°:Inversion; E°:Eversion.

When the relationship of foot and ankle parameters to pain severity and pain frequency in unhealthy volunteers was examined, it was observed that there was a negative correlation between DF° and E° values and pain frequency, and between DF°, PF° and E° values and pain severity in the right foot. In the left foot, a negative correlation was found between the DF° values and the frequency of pain. (p<0,05, Table 2).

Table 3. Investigation of bilateral asymmetry between foot and ankle parameters in unhealthy volunteers

Parameters	Right foot and ankle (Mean±Sd)	Left foot and ankle (Mean±Sd)	P value
FI	38,46±2,05	38,80±1,60	0,285
CSI	34,40±6,62	34,97±6,30	0,725
SI	60,44±10,07	60,99±9,85	0,930
C	48,71±8,63	49,43±9,68	0,641
DF°	13,09±10,04	14,52±9,26	0,462
PF°	64,76±6,82	63,57±7,85	0,751
I°	35,76±7,23	36,04±10,33	0,869
E°	23,90±12,46	19,48±13,41	0,129

Mann-Whitney U test (p<0,05). FI:Foot Index; CSI: Chippaux-Smirak Index; SI: Staheli Index; C°:Clark Angle; DF°:Dorsiflexion; PF°:Plantar Flexion; I°:Inversion; E°:Eversion.

When bilateral asymmetry status of unhealthy volunteers was examined, no difference was found between the parameters (p<0,05, Table 3).

Discussion and Conclusion

According to the results of the study, when the foot and ankle parameters of the unhealthy and healthy volunteers were compared, a statistically significant difference was found between the two groups in the right foot regarding CSI, SI and DF° values. Also, a statistically significant difference was found in the left foot regarding CSI and SI values.

In the chippauxsmirak index (CSI), 0.1-29.99 is considered to be normal values (Echarri and Forriol, 2003). In this study, the CSI values of unhealthy volunteers were found to be 34.40±6,62 in the right foot, 34.97±6,30 in the left foot. On the other hand, the CSI values of the healthy volunteers were found to be 28.38±8,4 in the right foot, and 28.09±8,36 in the left foot. According to these results, it was seen that the foot structures of unhealthy volunteers had low arch structure, healthy volunteers had normal arch structure and there were statistically significant differences between the arch levels of the two groups.

In the study, SI values of unhealthy volunteers were found as 60,44±10,07 in the right foot and 60,99±9,85 in the left foot. SI values of healthy volunteers were 48,63±12,65 in the right foot and 49,44±13,99 in the left foot. In SI values, 30-59 interval is accepted as normal arc and over 59 is considered as low arc (Staheli et al., 1987). The SI values in the study show low arc in both feet in unhealthy volunteers.

Structural effects of arches are known in the absorption of all pressures applied to the human body during stopping and movement and transferring them to the ground. It is emphasized that the measures taken on damaged arch structures increase sports performance and prevent injuries (Huang et al., 1993; Kogler et al.,1996; Prachgosin et al., 2015; Zhao et al., 2017). Tong and Kong (2013) stated that the arch structure of the foot was associated with lower extremity injuries. Menz et al. (2016) emphasized that the flatness of the feet is associated with foot disorders, and interventions that change the abnormal foot posture may play a role in relieving and treating pain. Regarding the relationship between arch structure and foot injuries, it is seen that the relevant literature is similar to this study.

When the relationship of foot and ankle parameters to pain severity and pain frequency in unhealthy volunteers was examined,it was observed that there was a negative correlation between DF° and E° values and pain frequency, and between DF°, PF° and E° values and pain severity in the right foot. In the left foot, a negative correlation was found between the DF° values and the frequency of pain.

In this study results, dorsiflexion angle of the right ankle was significantly lower in the unhealthy group (13,09±2,28) than in the healthy group (19,71±1,74). In addition, when it was examined in terms of pain frequency and pain severity, it was observed that there was a negative correlation between DF values and the frequency and severity of pain. While Wiesler et al. (1996) stated in a study that dancers who had an injury had lower dorsiflexion than healthy dancers, Porter et al. (2002) also emphasized that the increase in achilles tendon flexibility in painful heel syndrome reduces pain. It is seen that similar studies support the results of this study.

The research model used in this study is a relational model based on situation determination. Therefore, the decrease in the joint range of motion of the injured volunteers may be due to the injuries.Researchers have emphasized that decreased flexibility for various reasons will cause new injuries and lead to loss of performance. Especially, dancers need higher ankle flexibility against injury (Abraham et al., 2016; Motta-Valencia, 2006; Rein et al., 2011; Russell et al, 2008).

In this study, some components of the foot morphological structure and ankle flexibility properties were found to have a relationship with foot and ankle disorders. These results can be taken into consideration in determining risk factors and preventive measures in terms of pain, injury and various ailments in the foot and ankle area.

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.681

Study Of Mental Health And Effective Communication On The Performance Of Active Treatment Staff Hospitals In Mashhad

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Type: Research Article (Received: 28.12.2022 – Accepted: 05.06.2023)

Abstract

The aim of this study was to investigate the effect of mental health and effective communication on the performance of athlete treatment staff in hospitals in Mashhad. The method of this research is descriptive and in terms of the method of implementation, is a part of the correlation method, and in terms of purpose, is among applied research. The statistical population of the study was all personnel of the hospitals staff of Mashhad. According to the work shift and the conditions of each of the personnel, 131 individuals were selected as the statistical sample using available sampling. The tools used in this study are three types of standard questionnaires General Health Questionnaire (GHQ), Effective Relationships Susan & Cernus (1979) and Job Performance Paterson's (1970) which are LIKERT Four, Four, and Seven Values designed. In this research, after collecting information using SPSS, descriptive statistics method was used to describe demographic variables and Pearson correlation, regression analysis, single sample T-test, Kolmogorov-Smirnov test and Friedman test. The findings of the study showed that there is a significant difference between the mean mental health, job performance and its related components and their components with the hypothesized mean. Therefore, their mean is higher than the hypothesized mean of society. The findings also showed that there is a positive and significant relationship between mental health and effective communication with job performance. Also, in order to assess the ability of mental health components and effective communication in predicting the job performance of the medical education staff, 57% and 41% Changes in job performance are predicted.

Keywords: Mental health, Effective communication, Job performance, Medical staff

Introduction

Job is a major part of human social life. Job plays a fundamental role in fulfilling human social needs, such as the need for respect, by providing opportunities for employees to participate in work groups. Health is a necessary condition for playing social roles and people can be active if they are healthy (Asadzandi et al., 2010; Özkan et al., 2018). Mental health means a degree of balance that a person establishes between her behaviors and shows rational behavior in the face of social problems and social adaptation to her environment (Khaqanizadeh et al., 2006). Mental health dimensions include physical incompatibility, anxiety and insomnia, social dysfunction and severe depression. In the last few decades, improving the mental health of the job environment as one of the most important development and improvement of human resources in organizations has attracted more attention in Iran and abroad. For the progress and growth of the country in all fields, one should first use healthy, thoughtful and creative human resources because healthy physical and intellectual resources are used in economic, service, educational and industrial institutions to raise the level of exploitation (Nawabi Nejad, 2001). One of the most important areas of health development in societies is the health and treatment sector, which has a direct relationship with human health, and among them, the medical staff in hospitals is considered as a stressful occupational group (Lambert, 2007). Examining and determining mental health indicators is a very important necessity in assessing the state of mental health for practitioners and planners in this field to understand the important priorities of the mental health of the society and implement the presented programs optimally. Mental health indicators related to a population are one of the main criteria for evaluating the quality of that society's performance in providing healthcare services to the covered populations (Stone et al., 2010). Communication and how to direct them towards "organizational goals" is one of the issues that managers care about. This attention is due to the fact that managers have realized that effective communication with employees and understanding their communication motivations is a vital factor in the success of managers to achieve the designed goals of the organization. Communication allows employees of all levels in the organization to interact with each other, achieve desired goals, be supported and benefit from the formal structure of the organization. At the organizational level, communication creates cohesion and links between different parts of the organization and helps the organization in empowering and advancing its missions, and ultimately improving organizational performance and reaching a desirable level of it (Abbaspour and Baroutian, 2010). Obviously, taking care of the public health of people who work in hospitals is very important; but the requirement for this is very serious, the general health of the managers of these organizations is desirable. Managers with low general health not only try to shirk their responsibilities and reduce their effectiveness and efficiency in performing duties, but they may also be effective in causing behavioral problems among employees (Bigler et al., 2013). One of the most important areas of health development in societies is the health and treatment sector, which has a direct relationship with human health, and among them, the staff working in hospitals, especially the nursing group, is considered a stressful job group, Various studies have been conducted in the field of stress, job satisfaction and to a lesser extent in the field of mental health among nurses, and factors such as workload and lack of appropriate support systems, insidious communication with sick and dying patients, moving between departments Different factors and connection with different cases, lack of cooperation and mutual understanding by patients and their companions and their families, personnel and many other factors have been identified as important factors in creating stress and reducing psychological level in this case (Araste et al., 2007). Various researches have been conducted in the field of mental health and work performance, and each of these researches has reached different results. The results of Bigler et al.'s research (2013) on executive managers of Tehran University of Medical Sciences showed that there is a direct correlation between the variables of anxiety with physical disorders, depression with physical health, anxiety and social functioning disorder. In their research on the employees of the Shahid Rajaei Medical Training Center in Qazvin came to the conclusion that mental disorders have a moderate prevalence among the employees of this hospital; Therefore, it requires more attention from officials and researchers to improve their mental health status by developing intervention programs (Sadeghi et al., 2010). In research entitled "Study of effective intra-organizational communication on the performance of employees of Hamedan Water and Sewerage Company" concluded that the effectiveness of communication in the society under investigation was slightly below the average level and considered the employees' performance to be average and a positive correlation and a strong relationship between the index of human relations and performance has been obtained (Maleki Ranjbar 2005). Conducted research related to management health and productivity (Kristen 2008). The results showed that working lifestyle as a psychological factor in the work environment can increase the productivity of employees. Considering the issue of health and its physical, mental and social aspects, the complete lack of attention to the psychological aspect of the issue and the complications and difficulties in defining and evaluating it, Increasing prevalence of mental disorders in developing countries and its low priority in social and economic development planning, The ever-increasing growth of the population and the problems corresponding to it, Major changes in the world during the last two decades in the field of epidemiology of diseases and health needs of people, Substitution of non-communicable diseases (characteristics of mental illness) with communicable diseases and placing mental disorders at the top in causing disability and premature death and published statistics on the prevalence of mental disorders in different countries, It increases the necessity of conducting such studies (International Labor Organization, (2000).

The purpose of this study is to investigate the mental health and effective communication on the performance of active medical staff in Mashhad hospitals, and so far no studies have been conducted on the general health status and effective communication with the occupational performance of employees in these hospitals, It is hoped that by conducting this study and determining the state of mental health and communication and work performance of employees, Valuable information should be available to managers and experts to prevent, control, treat and predict direct costs and create effective communication and the level of job performance of employees in line with the organizational goals of the hospital.

Material and Method

The method of carrying out this descriptive research and in terms of implementation method is part of the correlation method and in terms of purpose it is included in the category of applied research. The statistical population of the research is all medical staff (medical and paramedical) of Imam Reza (AS) Hospital and Qhaem (AS) Hospital, which is 900 people. Therefore, using available sampling method, 56 doctors, 8 paramedics, 54 nurses and 13 paramedics were selected as a statistical sample. The data collection tool is three types of standard questionnaires: 28-question General Health Questionnaire (GHQ), effective communication of Susman and Krinos (1979) and job performance of Patterson (1970), which have Cronbach's alpha coefficient of 0.84, 0.89, 0.87, respectively. So, data collection using SPSS software, descriptive statistics and inferential statistics of Pearson correlation, regression analysis, sample t-test, Kolmogorov Smirnov test and Friedman test were used.

Findings

In the present study, 42.7% of doctors, 47.4% of nurses, and 9.9% of paramedics constituted the statistical population. The most participants with 45% are in the age group of 44 years and above and the lowest frequency with 15.3% is related to the age group of 31 to 37 years. The highest and lowest frequency based on the level of education with 45.8% and 26.0% are related to doctoral and bachelor's fields, respectively. Also, the highest and lowest frequency based on sports experience, with 42% and 15.3% respectively, are related to the group of people with "more than 6 years" and "2 years" of sports experience. Also, according to the significance level of the Kolmogorov Smirnov test, it showed that all three variables of mental health, effective communication and job performance with their components are more than 0.05, it is determined that the distribution of data related to the variables and its components is normal.

Table No. 1: Kolmogorov Smirnov test statistics of research variables and components

Row	Variable		Z score		The significance level
1	Mental health		0.14		0.052
2	Symptoms of physical disorder		0.17		0.07
3	Symptoms of anxiety and sleep disorders		0.15		0.23
4	Disruption of social functioning		0.18		0.055
5	Effective communication		0.18		0.24
6	Communication with subordinates		0.12		0.071
7	Communication with superiors		0.15		0.059
8	Communication with colleagues		0.17		0.062
9	Job Performance		0.25		0.09

Table No. 2: Correlation test between mental health and its components with job performance

Row	Variable		Pearson correlation		The significance level
1	Mental health and job performance		0.74		0.001
2	Symptoms of physical disorder and occupational performance		0.61		0.001
3	Symptoms of anxiety and sleep disorders and job performance		0.68		0.001
4	Disruption of social functioning and job performance		0.58		0.001
5	Depressive symptoms and job performance		0.71		0.001

The results of the inferential statistics of the research show that there is a positive and significant relationship between mental health and all its components with job performance ($P<0.05$), so the correlation between mental health and all its components with high job performance was reported. In Table 3, the amount of correlation coefficient and explanation coefficient between mental health score and job performance has been determined, in which, since the correlation coefficient is equal to 0.74 and the explanation coefficient is equal to 0.54, it can be said that 54% of the changes in job performance It is related to mental health.

Table No. 3: Regression test

R	R	justified R^2	Watson camera statistics		The standard error of the explanation coefficient		The significance level
0.74	0.58	0.54	1.52		0.28737		0.001

Table No. 4: Regression variance analysis related to the impact of mental health variable on job performance

Source of changes	Fisher's statistics	average of squares	Degrees of freedom	sum of squares	The significance level
between groups	157.580	12.931	1	12.934	**0.001**
Intergroup		0.083	129	10.653	
Total			130	23.584	

As seen in Table 4, Fisher's test statistic is equal to 156.580 and the level of error is equal to 0.001, so the impact of mental health on job performance is confirmed.

Table No. 5: Model coefficients

		Not standardized coefficients	Standardized coefficients		
	SE	B	t	Beta	**Sig**
Stable	0.218	0.795	3.649		**0.001**
Mental health	0.062	0.773	12.51	0.740	**0.001**

The regression equation for calculating job performance is as follows: Job performance = 0.795 + 0.740 * (Mental health).

Other results of the research showed that there is a positive and significant relationship between effective communication and all its components with job performance ($P<0.05$), so the correlation between effective communication and all its components with job performance was reported as high.

Table No. 6: Correlation test between effective communication and its components with job performance

Row	Variable	Pearson correlation	The significance level
1	Effective communication and job performance	0.58	**0.001**
2	Communication with subordinates and job performance	0.50	**0.001**
3	Communication with superiors and job performance	0.63	**0.001**
4	Communication with colleagues and job performance	0.36	**0.001**

In Table 7, the correlation coefficient and the explanation coefficient between the score of effective communication and job performance have been determined, in which, since the correlation coefficient is equal to 0.58 and the explanation coefficient is equal to 0.33, it can be said that 33% of performance changes A job related to effective communication.

Table No. 7: Regression test

R	R^2	justified R^2	Watson camera statistics		The standard error of the explanation coefficient		The significance level
0.58	0.34	0.33	1.78		0.34662		0.001

Table No. 8: Regression variance analysis related to the effect of effective communication variable on job performance

Source of changes	Fisher's statistics	average of squares	Degrees of freedom	sum of squares	The significance level
between groups	67.293	8.085	1	8.085	**0.001**
Intergroup		0.120	129	15.499	
Total			130	23.584	

As seen in Table 8, Fisher's test statistic is equal to 67.293 and the level of error is equal to 0.001, so the effect of effective communication on job performance is confirmed.

Table No. 9: Model coefficients

		Not standardized coefficients	Standardized coefficients		
	SE	B	t	Beta	**Sig**
stable	0.461	0.268	0.582		**0.001**
Effective communication	0.074	0.604	8.203	0.586	**0.001**

Discussion and conclusion

The findings of the mental health variable showed that the mental health status of the statistical population is relatively favorable. Research shows that the presence of high-level and quality communication at work can lead to a reduction in role ambiguity, job stress, increase job satisfaction and improve employee performance. Recent researches state; If accurate, appropriate and timely information is given to the employees about the changes in the educational system, there is less possibility that these changes will lead to endangering the mental health of the employees. Therefore, it is important that employers provide employees with sufficient information about policies, changes and work operations. Employers should also look for ways to adapt work to the values of employees so that work is meaningful for them. Having mental problems leads to disruption in performing tasks, reducing the motivation, anxiety, fear and worry, and causes a person to spend a significant part of his mental energy on such problems. As a result, it is certain that he will not have enough power and interest to work in the organization. Since human power is one of the biggest resources and capital of any organization, its health plays a decisive role in increasing productivity. Therefore, any planning and investment in this sector that leads to maintaining and improving the health level of employees, can ultimately lead to an increase in efficiency and be associated with the return of capital. Studies conducted in the field of mental health in different countries have mentioned a figure between 34-48.8 percent for mental disorders among nurses, which is consistent with the results of the present study. The findings of Sahebi's study (2006) also showed that the prevalence of mental disorders among nurses is the highest. According to the International Institute of Occupational Health and Safety, nurses are ranked 27th among 130 professions in terms of occurrence of mental illnesses. At the organizational level, communication creates cohesion and connection between different parts of the organization and helps the organization in empowering and advancing its missions and ultimately improving organizational performance and reaching a desirable level. The results of the present research with the results of the researches of Bigler et al. (2013), Sadeghi et al. (2010), Habibi et al. (2008), Arasteh et al. (2007), Bovier et al. (2009), Hong et al. (2005), are consistent. Also, the results of the research showed that the average score of effective communication and its components indicates a favorable situation, so that their average score was reported to be more than 4. Also, the results of the research showed that the average score of job performance indicates a favorable situation, so that the average score was reported to be more than 3. In order to survive and progress in today's competitive world, organizations have to direct a major part of their efforts to processes and functions that play an essential role in their success and performance improvement. One of the effective processes in improving organizational performance is effective communication, which can play a significant role in organizational performance if effective criteria are used. In the process of creating effective organizational communication, managers will be able to communicate between all the different departments of an organization by observing the effectiveness criteria and also having common beliefs, values and creating a common understanding of goals between people and also help to the organization in empowering and advancing the missions and finally improving the organizational performance and reaching its desired level. The results of the present research with the results of the researches of Sadeghi et al. (2010), Habibi et al. (2008), Salimi et al. (2009), Bovier et al. (2009), Hong et al. (2005), Kristen (2008), patty et al. (1997), are consistent. In order to pay attention to the evidence and research results obtained from the statistical data, suggestions are made to improve the performance of the educational and treatment system of the hospital in order to increase the productivity and efficiency of medical and non-medical staff: Considering that the mental health of the employees of this hospital is at a favorable level; However, in order to maintain the desirability, it requires more attention from the officials in this field. Therefore, compiling several intervention programs such as improving sleep status, providing facilities for sports activities in hospital employees, gaining their satisfaction as much as possible, will have a great effect on improving their mental health status. Strong communication and supportive management increase mental health and reduce mental disturbances and increase the level of mental health of employees. For this reason, it is suggested that the managers provide the mental health of the medical staff with their supportive leadership style, and the educational system organizes short-term in-service training courses on mental health and effective communication. Because mental health and effective communication have a direct impact on improving the occupational performance of medical staff. Also, the hospital counseling center should evaluate the medical staff in terms of positive and negative emotions and mental health and inform them about their mental health.

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International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.682

Testing and Tuning of the Sport Archery Bow and Arrow System

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Type: Research Article (Received: 12.08.2022 – Accepted: 19.06.2023)

Abstract

Background. Testing and tuning of the archery bow and arrow system is an important component for successful shooting. The aim of the research is to develop an analytical method of the virtual testing and tuning of the archery bow and arrow system and optimizing of the height of the plunger and arrow rest. *Materials and Methods. Modern recurve bows in the frames of International Archery Federation standards are studied.* Modeling is used to derive a method of preparation of the bow for sport archery competition. A model of the archery bow as a kinematical chain with solid members united with rotated kinematical pairs is investigated. *Results.* The bow and arrow system was studied in the braced and drawn situations, and methods of virtual testing and optimizing of the height of the plunger and arrow rest above the hand is developed. The bow and arrow with a zero angle of attack can not be symmetrical in the main plane because an arrow and a hand that holds a bow could not situated together at the same place. *Conclusion.* The results of modeling are presented in a simple form (as tables and figures) which are suitable for coachers and shooters who are unready to use the mathematical methods.

Keywords: shooting, archer, recurve bow, modeling.

Introduction

The archery shooting is ruled by World Archery Federation documents and standards (World Archery rulebook, 2017). Accuracy of the archery shots is depended upon quality of the bow and arrows. A tuning of the archery bow and arrow system is an important element for successful shooting. There are two adjustments to be made in tuning of any bow. The first is done in the vertical plane and almost always involves only adjustment of the nock point. The second adjustment is done in the horizontal plane and involves an adjustment of the pressure point, the amount of centre shot. Two empirical types of testing are used in the archery practice: the bare shaft tests developed by Max Hamilton and Steve Ellison test (Ellison, 2018). These tests aim the tuning of the bow and arrow system in the vertical plane.A basic tuning test is a simply shooting an arrow horizontally at a target from a distance of about 3–5 m. This quick test gives a fair 'coarse alignment' check. An archer observes whether the tail of the arrow 'lays over' to left or right, or is high or low. This test is more sensitive using a bare shaft instead of a fletched shaft. The nock point adjustment test is affected by tillering; tiller adjustment may be out if the nocking point is hard or impossible to adjust.It is best to check by shooting several arrows, into different places on the target. If the test looks right, the test should be repeated at one or two other distances: 3 and 6 m. If these are right too, things are about right. If not, adjust until the shafts are straight at several distances, or a different test should be used (Ellison, 2016). A walk-back test gives a useful combined test of both center shot and button tension. The test is done in calm conditions, and while an archer are shooting normally. In particular, an archer should be warmed up and has shot enough practice arrows to be close to the typical competition shooting. The 'paper plate' test is suggested by Tim Roberts for compound tiller tuning. However, identical principles apply for any other fine tuning adjustment, so the method could be used for a variety of adjustments. The paper tear test gives a good indication of both vertical and lateral adjustment. It relies on a simple indication of early arrow flight. It uses fletched shafts, but needs other equipment to hold paper in front of a target (Arrow Tuning and Maintenance Guide, 2019).So, the tests which are used to tune the bow arrow system entail considerable effort and much time. They are based on laborious procedures through a lengthy and complicated trials and error phase. Furthermore, these tests allow only the variation of one parameter: the nock height of the arrow. Another variable which is believed to be important is not taken into consideration in the frames of the methods. Among others, it is the initial setup angles of the limbs relatively to the riser. Therefore, the **aim** of the research was to develop analytical methods of the virtual testing and tuning of the archery bow and arrow system and optimizing of the height of the plunger and arrow rest.

Bow and arrow modeling

The first results dealing with the static strains and stresses in a drawn bow have been published by Hickman (1937). His articles have shown the effect of the shape and form of bending of the bow upon these strains and stresses. Some interesting and valuable information was obtained from that work which has materially changed the design of modern bows. He designed Lagrange function of one degree of freedom and corresponding equation of motion. An arrow was modeled as a particle placed at the axis of symmetry of the system. A third part of the string mass was added to the mass of the arrow and the rest – to the limbs.

A successful attempt to creation of the mathematical model of the archery bow and arrow system was done by Klopsteg (1943). He developed a mechanical engineering model of the long bow as a plane symmetrical kinematical chain of solid rods united with rotated kinematical pairs and un-stretched string. Two straight rigid beams hinged with a handle were introduced instead of the real flexible limbs. A stiffness of the bended limbs was modeled with a spiral spring mounted into the rotation kinematic pairs. Approximately linear correlation between the bow force and the drawn distance was derived as a solution of the static problem and as a result of the experimental data.

Ballistics of the modern-working recurve bow and arrow was studied by Schuster (1969). A model of the working recurve bow amenable to analytic solution was developed. The equations of motion of the bow and arrow system were obtained and numerically integrated by computer. It was shown that subject to the approximations, the system is 100% efficient. Variations of the transfer of energy between bow and arrow were discussed in terms of bow parameters and the effects on the archer. A discussion of first-order exterior ballistics and arrow penetration indicated the equipment characteristics most desirable for both the target archer and hunter, subject to the archer's own capabilities.

Marlow (1981) presented analysis of a bow with an elastic string. It is found that arrow exit then takes place when the string and bow limbs still have substantial kinetic energy, and therefore this energy is unavailable for kinetic energy of the arrow. Moreover, the potential energy remaining in the string and bow limb system can also reduce the amount of energy available for the arrow. For the Hickman model of a long bow used in this study, the elastic string prediction of efficiency is 78%, whereas the inelastic prediction is 92%. The analysis utilizes a Lagrangian distributed mass formulation to develop the governing equations of motion and to generate an equivalent point mass model. Estimates of the effect of air resistance were made and found to be less than 2% of the total system energy. The vibratory dynamics of the string and bow limbs subsequent to arrow exit was analyzed.

A wide and accurate experimental and theoretical research in archery was done by Pekalski (1990). The aim of his study was to introduce certain methods and research techniques and to present the results of experiments on parameters of archery equipment to optimize the interaction of the archer – bow – arrow system's elements. The mathematical modeling and computer simulation were used to describe the arrow's movement for various initial conditions and various parameters of the equipment, based on which a nomogram was constructed of the optimum arrow parameters for bows of various draw forces. The device for the mechanical loosing of arrows from a bow was used to study the influence of selected parameters of the archer – bow – arrow system on the accuracy of shots. The film analysis was used to verify the mathematical and mechanical models constructed.

The design parameters associated with the developed model are charted accurately. These and other important problems were studied by Kooi (1991). Bows used in the past and nowadays on shooting meetings such as the Olympic Games are compared. It turns out that the application of better materials which can store more deformation energy per unit of mass and that this material is used to a larger extent, contribute most to the improvement of the bow. The parameters which fix the mechanical performance of the bow appear to be less important as is often claimed.

The arrow needed to get round the bow while being accelerated; this phenomenon is called the Archer's Paradox. In the forties it was observed experimentally with high-speed cameras that the arrow vibrates in a horizontal plane perpendicular to the vertical median plane of the bow. These movements are started and controlled by the movements of the two points of contact with the bow. The middle of the string is in contact with the rear end of the arrow and the grip where the arrow slides along the bow. The latter contact imposes a moving-boundary condition. The numerically obtained results are satisfactorily in agreement with experimental data. The model can be used to estimate the drawing force of ancient bows of which only the contemporary arrows are available and also for the design of new archery equipment (Kooi and Sparenberg, 1997). Vibration processes in the compound and open kinematical chain with an external link, as a model of an archery bow and arrow system, were evaluated. A mechanical and mathematical model of bend oscillations of the system during accelerate motion of the external link was proposed. Correlation between longitudinal acceleration and natural frequencies was obtained. There are recommendations regarding determination of virtual forms to study arrow vibrations and buckling. The models and methods have been adapted for realization into the engineering method using well-known mathematical software packages (Zanevskyy, 2009).

Theoretical and experimental results of research on the problem of archer, bow and arrow behavior in the vertical plane are presented. The aim of the research was to develop a method of computer simulation of static and dynamic interactions between the archer, bow and arrow system in order to provide archery with practical recommendations. A model of an archer's body was presented as a mechanical system composed of a few solid bodies, which are connected to each other and to the ground with viscoelastic elements. Mechanical and mathematical model of bow and arrow geometry in vertical plane in braced and drawn situations was investigated. An asymmetrical scheme, rigid beams, concentrated elastic elements and elastic string are the main features of the model. Numerical results of computer simulation of archer, bow and arrow interactions were presented in graphical form, which makes the methods easy to use by sportsmen and coaches (Zanevskyy, 2006a).

Competition results in sport archery depend to a great extent upon the optimal combination of bow-arrow-archer system parameters. A significant part of bow tuning is vertical adjustment, the aim of which is to give an arrow zero angle of attack. It is conducted in a long and complicated manner and error correction takes a lot of time and effort. The goal of the research was to create an analytical method to determine an optimal combination of bow parameters, which ensures zero angle of attack for an arrow launched from a string. Mechanical and mathematical models of bow and arrow geometry in the vertical plane in braced and drawn situations were investigated. An asymmetrical scheme, rigid beams, concentrated elastic elements and elastic string were the main features of the model. Numerical results of a computer simulation are presented in tabular and graphical form, which makes it easy for sportsmen and coaches to use (Zanevskyy, 2006b).

Park (2009) studied a compound archery bow dynamic model, suggesting modifications to improve accuracy. This paper provides a model for the nock point locus in the vertical plane. While examples are provided for several configurations of compound bow, it is generally applicable to longbows and recurve bows as well. It was noted that asymmetric degrees of freedom in the cam configuration of a compound bow are required if the nocking-point locus is to be both straight and perpendicular to the rest position of the string, and that this cannot be achieved for some compound-bow configurations or for a longbow or recurve bow unless the arrow pass is in the geometric center of the string.

Materials and Methods

Modern recurve bows in the frames of International Archery Federation standards were studied. Mechanical and mathematical modeling was used to derive a method of preparation of the bow for sport archery competition. A drawn bow with an arrow is not symmetrical in its main (vertical) plane because a hand which holds the bow and the arrow cannot be situated simultaneously on the line of symmetry (Figure 1). Therefore, an asymmetrical mechanical chain was used as a modified model of the bow and arrow system in the virtual plane. Because the arrow is situated above the hand which holds the bow, the upper branch of a string should be shorter than the lower branch. Geometry of the scheme model was circumscribed with the equations as follows (Figure 2):

$$l_a = l_U \sin\theta_U + S_U \sin\gamma_U, \ (1) \quad y_A = h_U + l\cos\theta_U - S_U\cos\gamma_U, \ (2),$$

$$l_a = l_L \sin\theta_L + S_L \sin\gamma_L, \ (3), \quad y_A = S_L\cos\gamma_L - l\cos\theta_L - h_L, \ (4),$$

where l_a = length of an arrow, l = length of a limb; S_U, S_L = length of the upper and lower string branches, $\theta_U, \gamma_U, \theta_L, \gamma_L$ = angles between limbs and string branches positions and a handle, $h = h_U + h_L$ = length of the handle and its upper and lower branches. As rule, modern archery bows are equipped with equal limbs: $l_U = l_L = l$. A pivot point situates in the middle of the handle: $h_U = h_L = \frac{h}{2}$.

Because the asymmetry of the bow in the vertical plane is not considerable relatively its size (~3%), the nonlinear system of equations (1) – (4) was transformed to a linear regarding the corresponding symmetrical system (Zanevskyy, 2009):

$$l_a = l\sin\theta + \frac{S}{2}\sin\gamma; \ 2l\cos\theta + h = S\cos\gamma, \ (5)$$

where θ, γ, S are geometrical parameters of this virtual symmetrical system. Parameters of the real asymmetrical model correlate with parameters of the symmetrical model according to the equations below:

$$\theta_U = \theta + \Delta\theta_U; \ \theta_L = \theta + \Delta\theta_L; \ \gamma_U = \gamma + \Delta\gamma_U; \ \gamma_L = \gamma + \Delta\gamma_L; \ \varphi_U = \varphi - \Delta\varphi; \ \varphi_L = \varphi + \Delta\varphi, \ (6)$$

where φ = angle of the initial position of the limbs. There are two sources of the bow asymmetry. One of them is a difference in the initial position of the upper and lower limbs $(\varphi_U < \varphi_L)$, and another is a difference in length of the upper and lower branches of the string $(S_U < S_L)$.

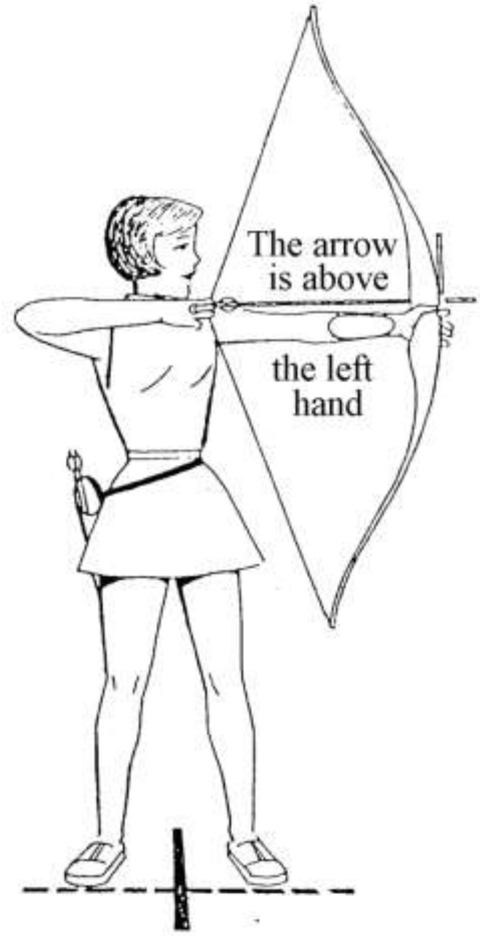

Figure 1. An archer with the drawn bow (Ellison, 2016)

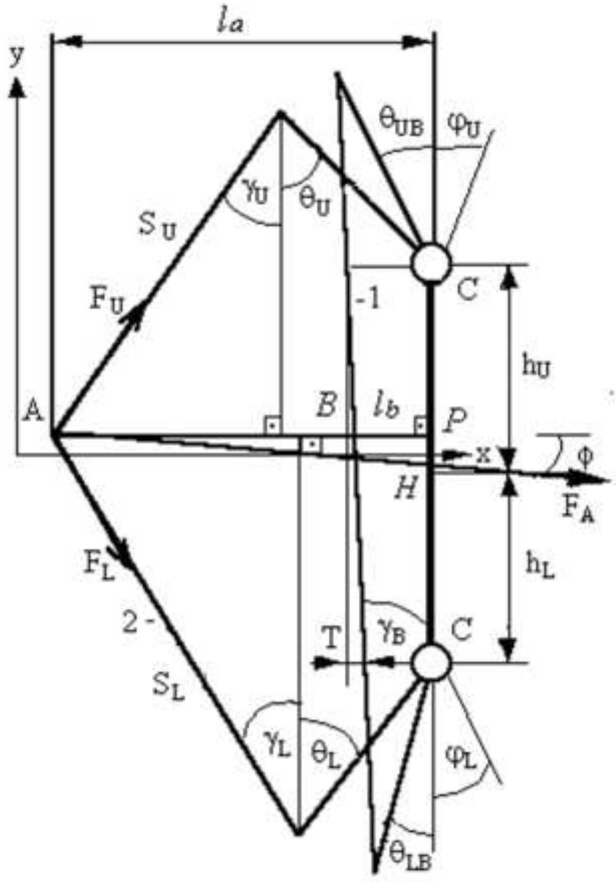

Figure 2. A scheme model of the bow and arrow in the vertical plane: 1 – braced situation and 2 – drawn situation.

The archery bow and arrow system is asymmetrical in its main plane, but the asymmetry of the system is not great: $\frac{S_L - S_U}{S_L + S_U} = \frac{\Delta S}{S} \sim \frac{\varphi_L - \varphi_U}{\varphi_L + \varphi_U} = \frac{\Delta\varphi}{\varphi} \sim 10^{-2}$; therefore, trigonometric functions of small angles were assumed as follow: $\sin\Delta\zeta \approx \Delta\zeta$, $\cos\Delta\zeta \approx 1$, where $S = S_U + S_L$ = length of a string, $\Delta\zeta$ = small angles $(\Delta\theta_U, \Delta\theta_{L,} \Delta\gamma_U, \Delta\gamma_L)$. Products of two small quantities were assumed zero as a number of the second power of a small quantity.

The problem on asymmetry was studied taking into account the length of the string branches: $S_U = \frac{S}{2} - \Delta S$, $S_L = \frac{S}{2} + \Delta S$.

Corresponding equations which made possible to derive expressions of small parameters $(\Delta\theta_U,\ \Delta\theta_L,\ \Delta\gamma_U,\ \Delta\gamma_L)$ were determined after insertion of the expression (6) into the equations (1)–(4):

$$l\sin(\theta+\Delta\theta_U)+\left(\frac{S}{2}-\Delta S\right)\sin(\gamma+\Delta\gamma_U)=l_a,\ y_A=\frac{h}{2}+l\cos(\theta+\Delta\theta_U)-\left(\frac{S}{2}-\Delta S\right)\cos(\gamma+\Delta\gamma_U),$$

$$l\sin(\theta+\Delta\theta_L)+\left(\frac{S}{2}+\Delta S\right)\sin(\gamma+\Delta\gamma_L)=l_a,\ y_A=\left(\frac{S}{2}+\Delta S\right)\cos(\gamma+\Delta\gamma_L)-\frac{h}{2}-l\cos(\theta+\Delta\theta_L).$$

After some algebraic transformations, a system of two linear equations relatively to small parameters $\Delta\theta_U, \Delta\gamma_U$ was derived:

$$l\Delta\theta_U\cos\theta+\frac{S}{2}\Delta\gamma_U\cos\gamma=\Delta S\sin\gamma,\ -l\Delta\theta_U\sin\theta+\frac{S}{2}\Delta\gamma_U\sin\gamma=y_A-\Delta S\cos\gamma.\quad(7)$$

Corresponding solutions of the equations (7) were derived as follow:

$$\Delta\theta_U=\frac{\Delta S-y_A\cos\gamma}{l\sin(\theta+\gamma)},\ \Delta\gamma_U=\frac{y_A\cos\theta-\Delta S\cos(\theta+\gamma)}{\frac{S}{2}\sin(\theta+\gamma)}.\quad(8)$$

After some algebraic transformations, a system of two linear equations relatively small to small parameters $\Delta\theta_L,\ \Delta\gamma_L$ was derived:

$$l\Delta\theta_L\cos\theta+\frac{S}{2}\Delta\gamma_L\cos\gamma=-\Delta S\sin\gamma,\ l\Delta\theta_L\sin\theta-\frac{S}{2}\Delta\gamma_L\sin\gamma=y_A-\Delta S\cos\gamma.\quad(9)$$

Solutions of the equations (9) were derived as follow:

$$\Delta\theta_L=\frac{y_A\cos\gamma-\Delta S}{l\sin(\theta+\gamma)},\ \Delta\gamma_L=\frac{\Delta S\cos(\theta+\gamma)-y_A\cos\theta}{\frac{S}{2}\sin(\theta+\gamma)}.\quad(10)$$

Comparing two pairs of solutions (8) and (10), one can write down: $\Delta\theta_U=-\Delta\theta_L$ and $\Delta\gamma_U=-\Delta\gamma_L$.

Equations of equilibrium of each of two limbs and of the bow itself in the drawn position situation were derived as follow:

$$c(\theta_U+\varphi_U)=F_U l\sin(\theta_U+\gamma_U),\ c(\theta_L+\varphi_L)=F_L l\sin(\theta_L+\gamma_L),\quad(11)$$

$$F_x = F_U \sin\gamma_U + F_L \sin\gamma_L,\ F_y = F_U \cos\gamma_U - F_L \cos\gamma_L,\ F_A = \sqrt{F_x^2 + F_y^2},\ (12)$$

$$tg\phi = -\frac{F_y}{F_x},\ tg\phi = \frac{y_A + (h_U - h_L)/2}{l_a},\ (13)$$

where ϕ = angle between the line of action of the force vector of the archer and the line of symmetry of the bow, c = virtual bending stiffness of bow limbs concentrated at the ends of the handle, F_A, F_x, F_y = bow force and its projections on the corresponding axes, F_U, F_L = forces of the upper and lower string branches, φ_U, φ_L = angles of limbs setup relatively to the handle. There are positive values of these angles – clockwise for the upper limb and counter-clockwise for the lower limb. The angles in the initial position of the recurve bow limbs are both positive and negative, and zero too.

Like to the transformation of the bow geometry to the linear system (6), the next equations were derived: $\frac{F_U - F_L}{F_U + F_L} = \frac{\Delta F}{F} << 1$, where $F_U = F + \Delta F_U$; $F_L = F + \Delta F_L$. The two last expressions were substituted into the equations (11)–(13), and equations as follow were derived:

$$F(\Delta\theta + \Delta\gamma)\cos(\theta + \gamma) + \Delta F_U \sin(\theta + \gamma) - \frac{c}{l}(\Delta\theta - \Delta\varphi) = 0,\ (14)$$

$$-F(\Delta\theta + \Delta\gamma)\cos(\theta + \gamma) + \Delta F_L \sin(\theta + \gamma) + \frac{c}{l}(\Delta\theta - \Delta\varphi) = 0.\ (15)$$

A sum of these two equations gave the equation bellow: $(\Delta F_U + \Delta F_L)\sin(\theta + \gamma) = 0$. (16)

Because geometrical parameters of long bare bows $(0 < \theta + \gamma < \pi)$, $\sin(\theta + \gamma) \neq 0$. Taking into account equation (16), one can conclude that $\Delta F_U + \Delta F_L = 0$ or $\Delta F_U = -\Delta F_L = \Delta F$:

$$\Delta F = \frac{\frac{c}{l}(\Delta\theta - \Delta\varphi) - F(\Delta\theta + \Delta\gamma)\cos(\theta + \gamma)}{\sin(\theta + \gamma)}.\ (17)$$

Equations of the force parameters (regarding the virtual symmetric system) were derived as follow: $c(\theta + \varphi) = F\sin(\theta + \gamma)$; $F_A = 2F\sin\gamma$. (18)

After a substitution of the last expressions into the system (1)–(4), (11)–(13), the followed system of linear (regarding parameters $y_A, \Delta\theta, \Delta\gamma$) equations was derived:

$$y_A = \Delta S\cos\gamma + \frac{S}{2}\Delta\gamma\sin\gamma - l\Delta\theta\sin\theta,\ (19),\quad \Delta S\sin\gamma - \frac{S}{2}\Delta\gamma\cos\gamma - l\Delta\theta\cos\theta = 0,\ (20)$$

$$\frac{y_A}{l_a} = \Delta\gamma - \left[\frac{\Delta\theta - \Delta\varphi}{\theta + \varphi} - \frac{\Delta\theta + \Delta\gamma}{tg(\theta + \gamma)}\right] ctg\gamma\ . \quad (21)$$

Equations of the braced bow were derived as follow:

$$l(\cos\theta_{UB} + \cos\theta_{LB}) + h = S\cos\gamma_B,\ l(\sin\theta_{UB} - \sin\theta_{LB}) = S\sin\gamma_B,$$

$$F_B l\sin(\theta_{UB} - \gamma_B) = c(\theta_{UB} + \varphi_U);\ F_B l\sin(\theta_{LB} + \gamma_B) = c(\theta_{LB} + \varphi_L), \quad (22)$$

where symbols signed with index "*B*" are used as parameters of the bow in the braced situation (see Figure 2). In the same way as it was done for the bow in the drawn situation, and taking into account geometry of the system $(\theta_{UB} + \varphi_U \approx \theta_{LB} + \varphi_L;\ \gamma_B << 1)$, one can write down the followed equations: $\theta_{UB} = \theta_B + \Delta\theta_{UB};\ \theta_{LB} = \theta_B + \Delta\theta_{LB},\quad \theta_B = \arccos\frac{S-h}{2l}$, $l_b = l\sin\theta_B,\ F_B = \frac{c(\theta_B + \varphi)}{l_b}$,

where θ_B = angle of a limb in the corresponding symmetrical bow system. Then in a similar manner to the equations (8) and (10), the equation was derived: $(\Delta\theta_{UB} + \Delta\theta_{LB})\sin\theta_B = 0$. Because in any position of the bow $0 < \theta_B < \pi$, one can write done: $\Delta\theta_{UB} + \Delta\theta_{LB} = 0$ or $\Delta\theta_{UB} = -\Delta\theta_{LB} = \Delta\theta_B$. As a result, parameters of the braced bow have been derived as follow:

$$\Delta\theta_B = \frac{\Delta\varphi\ tg\theta_B}{tg\theta_B - (\theta_B + \varphi)\frac{h}{S}};\ \gamma_B = \Delta\theta_B\left(1 - \frac{h}{S}\right). \quad (23)$$

Parameters of the system in the drawn situation of the bow were derived using the equations (19)–(21) and the scheme model:

$$\alpha = arctg\frac{h}{2l_a},\ \theta + \gamma = \arccos\frac{l^2 + S^2/4 - l_a^2 - h^2}{lS},\ \sin\beta = \frac{l\sin(\theta + \gamma)}{\sqrt{l_a^2 + h^2/4}},\ \gamma = \frac{\pi}{2} - \alpha - \beta\ .$$

The nock point distance on the string in its braced situation was determined using the equation as follow (see Figure 2): $y_B = \Delta S - l_b\Delta\theta_B$. (24)

A tiller difference was determined using the equation as follow: $T = h\gamma_B$. (25)

Position of the plunger that obtains a zero angle of attack of the arrow was determined using its coordinate on the handle with the equation bellow: $y_P = y_B - \frac{(y_A - y_B)l_b}{l_a - l_b}$, (26)
where y_A was determined as a solution of the system of equations (19)–(21). The system of equations (17)–(26) is a mathematical model of the optimal tuning of the bow and arrow parameters taking into account a zero angle of attack of the arrow. A scheme model of the testing and tuning procedure is presented on Figure 3.

Figure 3. Bow and arrow scheme system in the vertical plane: a – symmetric, b – asymmetric, c – asymmetric and tuned (A – nock point at the drawn and B – at the braced bow, F – arrow in the free flight just after the launch; ϕ – angle of attack).

Using the proposed mathematical model as equations (17)–(26), calculation experiments regarding the optimal parameters of the moden archery bows during their testing and tuning were done. The method of simple itterations was used for solving a system of transindent algebra equations (19)–(21) and the method of division of a section in half was used when divergence ittarations occurred. Calculations were done using a function FindRoot from a package of computer programs Mathematica (Wolfram Research).

Results

A modern sport archery bow Hoyt GM T/D4 was tested and tuned with aluminum and carbon composite arrows Easton-Beman (Arrow guide, 2015) with a purpose to approbate the mathematical model and the methods developed and described in the research. A bow and arrow system was studied basing on the initial parameters: h = 0.68 m, l = 0.52 m, S = 1.62 m, $\varphi = 0.083$ rad, c = 129 Nm, l_a= 0.72 m.

A calculable experiment covered a wide range of parameters of the system taking into account instructions of producers and recommendations of sport archery coaches and sportsmen. A four-factor variation of parameters was done: a difference in the length of upper and lower branches of a string varied up to 100 mm, a height of a plunger – up to 40 mm, and a difference in distances of a string to the upper and lower ends of the handle (T) – up to 18 mm.

Parameters of the braced bow were determined using equations (22) – (25). Parameters of the drawn bow were determined using equations (5), (18) and (18) – (21). Corresponding calculations were done using Mathematica programs. The optimal height of a plunger was determined using equation (26).

Main results of modeling were collected in Table 1. A remarkable result of modeling is in the almost constant range of a nock point height, i.e. independence of this parameter from the difference in angles of limbs setup at the handle. In the studied range of difference in the length of the lower and upper string branches ($2\Delta S = 20 - 100$ mm), a height of the nock point was in the range from 2 to 11 mm, and a height of a plunger relatively to a centre of the handle – from 5 to 38 mm. For the common height of nock point 6–10 mm, the difference in length of upper and lower branches of a string was 60–80 mm. For the common difference of the bow asymmetry measured as tiller (3–12 mm), a difference of angles of limbs at the handle setup is recommended from 0.004 to 0.017 rad.

Table 1. Results of modeling (mm) for the optimal tuning of archery bow parameters and zero angle of attack of an arrow

$\Delta\varphi$, rad	0.005			0.010			0.015		
T, mm	3.7			7.4			11.1		
ΔS, mm	y_A	y_B	y_P	y_A	y_B	y_P	y_A	y_B	y_P
10	9.1	7.9	7.4	5.4	5.8	6.0	1.8	3.8	4.6
20	21.7	17.9	16.2	18.1	15.8	14.8	14.5	13.8	13.4

30	34.4	27.9	25.0	30.8	25.8	23.6	27.2	23.8	22.2
40	47.0	37.9	33.9	43.4	35.8	32.4	39.8	33.8	31.0
50	59.7	47.9	42.7	56.1	45.8	41.3	52.5	43.9	39.9

The necessary height of plunger that makes possible a free displacement of the arrow over the hand that holds a bow is approximately 20–30 mm. From the results of modeling (see Table 1), one can determined a lower value of difference in the length of upper and lower string branches as 60–80 mm. It is remarkably to notice, that this parameter is not depended on the difference of angles setup. However, this parameter significantly determines the direction of the arrow movement.

Two variants of bow testing regarding the tuning of a bow with an equal ratio of the string branches and equal height of the nock point, but a different ratio of the angles of limbs setup were done. In the first example, zero tiller was assumed ($T = 0$), i.e. the angles are equal: $\Delta\varphi = 0$, $\Delta S = 40$ mm, $y_A = 61$ mm, $y_B = 40$ mm, $y_P = 31$ mm. In the second example, the recommended value of tiller was assumed as follow (Baudrillard, 2007): $T = 11$ mm, $\Delta\varphi = 0.015$ rad, $\Delta S = 40$ mm, $y_A = 46$ mm, $y_B = 34$ mm, $y_P = 29$ mm.

In the first example, the angle of the arrow launch direction with a normal to the handle $\left(\frac{y_A - y_P}{l}\right)$ was in 1.8 times greater than in the second example, i.e. increase of the difference in the angles of limbs setup causes deviation of the arrow off the normal direction of the arrow launch. This correlation is actual in all the rest practical combinations of bow parameters aimed a zero angle of attack of the arrow (see Table 1). Increase of this angle makes more comfortable of the conditions of holding of a bow because does not demand a significant difference in the height of handle and the nock point of a string. As a result, a setup of the lower limb with a greater angle that of the upper limb relatively a handle makes possible to decrease asymmetry of the drawn bow.

Correspondingly to the task of the archery shooting, an archer can use the methods of the bow and arrow tuning in different variants, but the initial parameter should be a height of the plunger. Modern archery bows are equipped with a special mechanism that is intended for tuning a position of the plunger. With other equal conditions, a minimum height of the position that obtains a free displacement of the arrow over the hand that holds a handle should be preferred. This is because increase of the height of the plunger causes increase of asymmetry of the bow in the vertical plane that complicates controlling of the bow and arrow system by the shooter (see Table 1).

After the plunger height was determined, a ratio of the string branches' length and a difference of the angles of limbs setup at the handle were determined. With other equal conditions, more comfortable for the archer is a smaller difference in length of the string branches. For the shooting on the long distances (70 – 90 m) azimuth angle of the arrow launch should be greater, therefore this difference should be minimal.

To decrease the difference in length of the string branches, the difference in the angles of limbs setup should be increased. But this increase causes decrease of the height of the plunger (see Table 1). The process of the bow and arrow tuning includes a selection of convenient variants and choosing among them the best regarding the difference in length of the string branches.

An imitation scheme describes the process of determination and selection of these convenient variants for the tuning of the bow and arrow system (Figure 4). For example, a height of the plunger was assumed $y_P = 20 - 30$ mm. A necessary difference between the length of the string branches (ΔS) and the difference in the angles of limbs setup $(\Delta\varphi)$ were determined from Table 1, and then a parameter of direction of the arrow launch $(y_A - y_P)$ was calculated (Table 2).

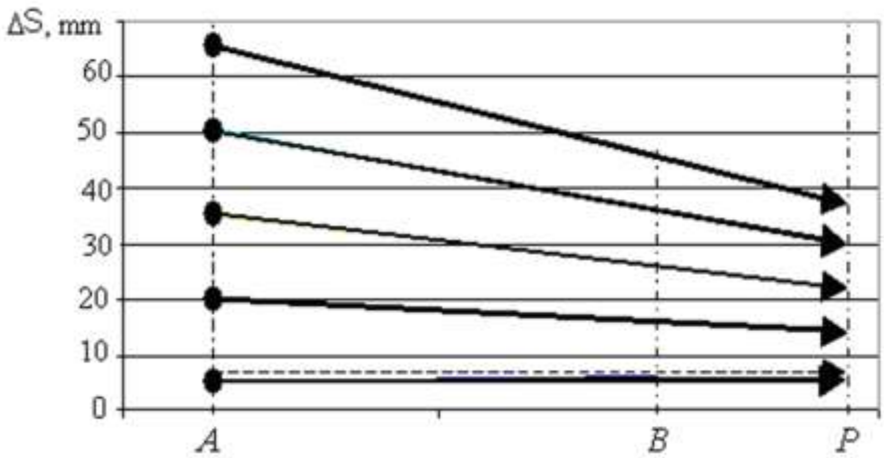

Figure 4. Results of virtual testing and tuning of the bow and arrow system to a zero angle of attack: *T*= 7.4 mm, *A* and *B* – situation of the nock point at the moments of string release and arrow launch correspondingly, *P* – plunger and rest.

Using a method of linear interpolation (i.e. calculation of intermeddle values between the values of the neighbor columns (see Table 1), the optimal values were determined. For example, corresponding formula for determination of the nock point coordinate in the braced position for $\Delta\varphi$= 0.015 and y_P= 20.0 mm was derived: $y_B = y_{B3} - (y_{P3} - y_P)(y_{B3} - y_{B2})/(y_{P3} - y_{P2})$, (27)

where sub-index figures signify ordinal numbers of lines in Table 1, y_{P2}= 13.4 mm, y_{P3} = 22.2 mm, y_{B2}= 13.8 mm, y_{B3}= 23.8 mm (see two last columns). Using equation (27) and analogous equations for a half difference in the length of string branches and nock point coordinate in the drawn position, these parameters were calculated: y_B= 21.2 mm, ΔS = 27.5 mm, and y_A= 23.9 mm.

Table 2. Values of parameters of bow and arrow system tuning (plunger height: $y_P = 20 - 30$ mm)

$\Delta\varphi$, rad	0	0.005	0.010	0.015	0.020	0.025

ΔS, mm	22.7–34.0	24.3–35.6	25.9–37.2	27.5–38.8	29.7–41.0	31.4–42.8
$y_A - y_P$, mm	8.7–13.1	7.1–11.5	5.5–9.9	3.9–8.3	3.2–7.5	1.8–6.1

Accuracy of the linear interpolation was estimated as a comparison of the calculated y_A with solutions of the system of equations (19)–(21) using FindRoot function. In the studied example an error was near 0.2%. In the frames of the model, results of the extrapolation for y_B and calculation by equation (24) were equal. Increase of the difference in values of the angles of the limbs setup from zero up to the maximum (0.025 rad) needs really negligible increase of difference in the lengths of the string branches (near 12 mm) that causes a significant decrease of the nock point height relatively to the handle (about 20 mm).

An optimal height of the plunger and arrow rest (y_p) was determined using the mathematical model (23)–(26). For the medial difference of the lower and upper parts of a string ($2\Delta S = 60$ mm) and asymmetry of a bow (T = 18 mm, y_B = 24 mm), the height of the plunger and arrow rest should be equal 20 mm, for T = 11 mm, y_B = 26 mm – 21 mm, and for T = 4 mm, y_B = 29 mm – 22 mm (Figure 5).

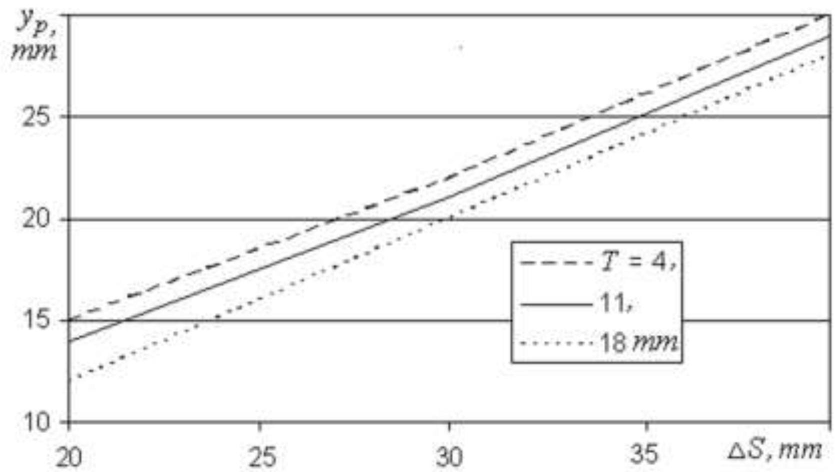

Figure 5. An optimal plunger height (y_P) vs. the difference of the string branches (ΔS) and the tiller difference (T).

For a greater difference of the lower and upper parts of a string ($2\Delta S = 70$ mm) and the same asymmetry of a bow, this height should be equal 24, 25, and 26 mm (y_B = 29, 31, 34 mm).

Discussions

The value of $y_A - y_P$ should be determined as minimum, but sufficient to obtain a free movement of the arrow above the arm that holds a bow. In the discussed example this value should be 18–20 mm that meets empirical recommendations for the tuning of the bow (Squadrone and Rodano, 1994).

Bow tuning in the vertical plane is a component of the whole process of the bow and arrow system (Park, 2011). Another component is adjusting of the bow and arrow movement in the lateral to the main plane. The aim of this adjustment is to avoid a stroke of the arrow tail to the handle that is known in theory and practice of archery as “archer paradox” (Peters, 2017). Corresponding mechanical and mathematical model of bow and arrow interaction in the lateral plane and the methods of tuning have been developed. Because amplitudes of bend vibrations of an arrow are a power smaller than a length of the arrow (Heller, 2012), linear model is suitable here. Using the linear model of shift vibration, one can assume non-significant correlation between modes of vibration in the two orthogonal planes, i.e. vertical and lateral. (Zanevskyy, 2001).

In the frames of the mechanical and mathematical model of the bow and arrow system that was derived and used in the adjusting of its parameters, it is reasonable to assume no influence of angle of attack on the lateral deflection of the arrow. Therefore parameters of the tuning of the system in the main plane and in the lateral plane are different, i.e. the process of tuning includes two different parts (Tiermas, 2017). As initial matter of the tuning are the main bow parameters: bow force, length of a handle, limbs, a string and the length of an arrow, which match anthropometrical parameters of an archer (Edelmann-Nusser et al., 2002).

A height of the nock point does not close depend on the difference the string branches length, but it is rather depended on the angles of the difference of the angles of limbs setup. The setup of the lower limb with a greater angle than the setup of the upper limb makes (Leroyer et al., 1993) possible to obtain smaller asymmetry of the drawn bow. The results of mathematical and mechanical modeling were presented in a simple form (see Tables 1,2 and Figure 5) that are suitable for coachers and shooters which are unready to use mathematical methods.

The analytical method of the virtual testing and tuning of the archery bow and arrow system developed in the research is recommended for the sport archery with a purpose of optimizing of the height of the plunger and arrow rest. An optimal regarding to the accuracy and the distance of shooting is a zero angle of attack of the arrow launch. To obtain this condition bow and arrow testing and tuning should be done. Well-known practical recommendations for the bow and arrow tuning are rather approximate and based on the empirical method of tests and mistakes. This method needs a long time and afford many efforts from archers during this testing. The bow and arrow system could not be symmetrical in the main plane because an arrow and a hand that holds a bow could not situated together at the same place. A zero angle of attack of the arrow could be obtained if a nock point of a string in the braced bow and the drawn bow, and a plunger are situated at the same straight line.

A modern sport recurve bow was described as a polygon with sides corresponding to the riser, the two limbs and the string. The string tension is generated by the torque in the limb joints with the torsion coefficient. The pivot point (where the bow is held) is fixed in the centre of the riser. The arrow length is equal the distance from the knocking point to the pivot point. A calculation method was prepared to assist in the task of tuning the bow. Parameters that are varied when tuning a bow are the location of the knocking point on the string, the location of the plunger on the riser where the arrow rests and the tiller as imbalance of the two limbs.

The main result was a determination of the unknown tuning parameters in terms of the given bow parameters, subject to one or more conditions that have to be met when the bow is tuned. The results of mathematical and mechanical modeling were presented in tables and graphs suitable for coachers and shooters which are not familiar with mathematical methods. The developed method is recommended for optimizing of the sport archery bow and arrow parameters.

**The research has been presented on the 8th International Conference on Science, Culture, and Sport (Cyprus, 17-20 May 2022).*

Acknowledgement

The research was supported by the Ukrainian Ministry of Education and Science.

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List of variables

c_U, c_L	Virtual stiffness of the upper and lower limbs
h	Length of a handle
h_U, h_L	Length of the upper and lower parts of a handle
l_U, l_L	Length of the upper and lower limbs

l_a	Length of an arrow
l_b	Distance of the pivot point to the braced string
A	Nock point in the drawn position
B	Nock point in the braced position
F_A, F_x, F_y	Force acting to a string by an archer's hand and its projections
F_U, F_L	Tensile forces in upper and lower string branches
F, c	Force parameters of the virtual symmetrical system
H	Pivot point
L	Sign of the lower part of a bow
P	Plunger and rest
S	String length
S_U, S_L	Length of the upper and lower branches of a string
x, y	Co-ordinates fixed to the handle
U	Sign of the upper part of a bow
α, β	Angles of the drawn symmetrical bow
γ_U, γ_L	Angles between upper and lower string branches and a handle
T	Tiller difference
ΔS	Half part of string branches length difference
$\Delta\zeta$	Small quantity
θ, γ, φ	Angles of the virtual symmetrical system
θ_U, θ_L	Angles between upper and lower limbs and a handle
φ_U, φ_L	Angles of the installed limbs to a handle
ϕ	Angle between the bow force vector and an arrow in the vertical plane

International Journal of Sport Culture and Science
June 2023 : 11(2)
ISSN : 2148-1148
Doi : 10.14486/IntJSCS.2023.683

The Acute Effects of Different Stretching Exercises on the Power and Agility of Adolescent Football Player

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Type: Research Article (Received: 22.02.2022 – Accepted: 19.06.2023)

Abstract

The aim of this study was to compare the acute effects of static and dynamic stretching exercises on the power and agility of adolescent male football players. Ten male football players (age 15.8 ± 1.47 years, height 1.66 ± 0.05 m, body weight 59.6 ± 10.7 kg, training age 3 ± 1.94 years) from a team competing in the Bitlis 1st Amateur Group B of the 2019/20 season voluntarily participated in the study. All subjects participated in control (warm-up only), static stretching (warm-up + static stretching) and dynamic stretching (warm-up + dynamic stretching) exercise groups, respectively, on non-consecutive days. All groups were given 10-minute warm-up exercises. After warming up, the control group was given 10 minutes of passive rest. For the main muscle groups, 10 minutes of static stretching was applied to one of the other two groups, and 10 minutes of dynamic stretching exercises were applied to the other. After 1-2 minutes of rest, T-drill, medicine ball throwing and vertical jump test measurements were taken from the athletes, respectively. The obtained data were analyzed statistically and the level of significance was determined as $p<0.05$. As a result of the research, while there was no significant difference between acute static stretching and dynamic stretching in terms of power performance, a significant difference was found in favor of dynamic stretching in agility performance.

Keywords: Static Stretching, Dynamic Stretching, Warm-Up, Power, Agility.

Introduction

Football, one of the most popular sports branches in the world and in our country; Since it is a simple, interesting and enjoyable game that is played by every segment of society and watched fondly at the same time, it has cost a large audience and won the love of millions of people (Şenel, 1999). Football is a high-intensity sport in which both aerobic and anaerobic efforts are used alternately, and motor skills such as speed, strength, power, flexibility, agility, cardiovascular endurance, muscular endurance and coordinative abilities affect performance together (Brown et al., 2018:283-284). The fact that this sport gains momentum and spreads to wider masses is because science and sports science contribute to football interactively (Günay et al., 2008).

Physiological requirements of our body (respiration, circulation, nervous, muscular systems, etc.) before training/competition are at the lowest level. These physiological needs cannot be expected to increase suddenly or spontaneously. Athletes should do warm-up and stretching exercises before training/competition in order to prepare the body physically and psychologically for these needs (Günay et al., 2017: 473). The main purpose of warming up is to accelerate blood circulation by increasing body temperature, the main purpose of stretching exercises is to improve performance by increasing joint range of motion or flexibility (Alp, 2016).

Since the early 1980s, static stretching before doing physical activity has been widely promoted as a method to prevent injury and improve physical performance (Small et al., 2008). Of the pre-training/pre-competition warm-up and stretching exercises, static stretching has traditionally been the most widely used, but whether incorporating this type of warm-up into a warm-up routine has a detrimental effect on agility and power generation has been investigated (Samuel et al., 2008; Yamaguchi et al., 2005; Young et al., 2003).

The link between static stretching and performance has been the subject of many studies. Studies have focused on speed, strength, flexibility and power to determine short-term anaerobic power. When the recent studies are examined, it is seen that the findings that other performance elements other than flexibility are negatively affected by static stretching exercises are intense. Studies have shown that both acute and chronic static stretching exercises reduce the risk of injury (İşleğen, 2013; Small et al., 2008) by increasing flexibility (Akyüz, 2017; Demirel et al., 2004; Depino et al., 2000; Göksu et al., 2003; Nelson et al., 2004; Yaşlı et al., 2019), which is an important performance feature for athletes. Contrary to these studies, in some studies, acute static stretching exercises negatively affect performance items such as agility (Chatzopoulos et al., 2014; McMillian et al., 2006), explosive force (Young et al., 2001), maximal strength (Bacurau et al., 2009), power (Marek et al., 2005; Samuel et al., 2008; Yamaguchi et al., 2005), peak torque (Cramer et al., 2004), speed (Winchester et al., 2008; Yıldız et al., 2013), reaction and movement time (Behm et al., 2004), or they cannot be added at all.

Based on previous studies showing a decrease in vertical jump height after static stretching, it is assumed that there will be an acute decrease in vertical jump after static stretching, while performing dynamic stretching will increase vertical jump (Fattahi-Bafghi et al., 2012). Recently, dynamic stretching exercises have come to the fore. In a study, it was suggested that voluntary contractions to be performed from a moderate level such as dynamic stretching before training/competition to high intensity will activate the muscle-nervous system and increase power production (Bishop, 2003). In some studies, it has been reported that acute dynamic stretching exercises increase performance elements such as power (Manoel et al., 2008; Yamaguchi et al., 2005), strength (Young et al., 2003), agility (McMillian et al., 2006; Polat et al., 2019), flexibility (Atan, 2019; Perrier et al., 2011) and speed (Akyüz, 2017).

Contrary to these studies, some studies have suggested that acute dynamic stretching exercises negatively affect or do not affect performance items such as power (Behara et al., 2017; Fattahi-Bafghi et al., 2012), agility (Shaji et al., 2009), flexibility (O'Sullivan et al., 2009). Many explosive performance elements are required in football, including jumping, kicking, picking up the ball from the feet, sudden changes of direction, running, changing speeds, and sustaining strong contractions (Stolen et al., 2005). In addition to these, the individual is in a state of mobility throughout his life from the beginning of life. This mobility is not the same at all stages of life and may differ. Mobility is extremely high because school-aged and pre-school children have more internal impulses. Although there is a decrease in the movements of the individual during the period of puberty, it has been determined that there are improvements in the older ages (15-19) (Gündüz, 2017). There are not enough studies in the literature on the effects of stretching on the performance of amateur football players in this transitional age.

The aim of this study is to determine the development of adolescent male football players in terms of power and agility performance after acute static stretching and dynamic stretching exercises and to compare and evaluate the effects of stretching exercises.

Material and Method

Experimental Approach to the Problem

The research was carried out after obtaining the necessary approval from the Gazi University Ethics Commission (dated 30/12/2019 and decision no E/134861). This study, which examines the effects of acute stretching exercises on the power and agility of adolescent boys, was applied based on the "experimental research model".

The schematic view of the method used in the research is as follows;

1.Day	S	G1	I	X	T
3.Day	S	G2	I	Y	T
5.Day	S	G3	I	Z	T

Figure 1. Schematic View of the Method Used in the Research. S: Group of the same people (n=10), G1: Warm-up, G2: Warm-up + static stretching, G3: Warm-up + dynamic stretching, I: Warm-up protocol, X: Rest (10min), Y: Static stretching protocol (10min), Z: Dynamic stretching protocol (10min), T: Performance tests (T-drill, medicine ball throw, vertical jump).

The current research protocol was taken from a highly cited article (McMillian et al., 2006) and adapted to the circumstances at hand. All subjects participated in warm-up, warm-up + static stretching, and warm-up + dynamic stretching groups, respectively, on non-consecutive days. During the warm-up phase, all participants were given a total of 10 minutes of exercise as 8 minutes of warm-up run and 2 minutes of jog. After warming up, the control group was given 10 minutes of passive rest. For the main muscle groups, 10 minutes of static stretching was applied to one of the other two groups, while 10 minutes of dynamic stretching protocols were applied to the other. After resting for 1-2 minutes, all participants participated in T-drill, medicine ball throwing and vertical jump performance tests twice and their best results were recorded. Full rest was applied between tests. The study was carried out in the open area (Tatvan City Stadium) and the air temperature was taken from meteorology on 17, 19, 21 May 2020 as 1st Day 20°, 3rd Day 20° and 5th Day 21° (Accuweather, 2020). During the experiment, subjects were given feedback to improve the proper conduct of both warm-up techniques and performance measures.

All subjects received orientation training for both stretching exercises and performance tests one week beforehand. During the research process, it was recommended that the athletes not do any sports activities other than their warm-up routines and continue their daily eating habits without applying any special nutrition program. Care has been taken to avoid tasks that cause fatigue, as fatigue has been found that inhibit local muscle performance, particularly for tasks involving a stress-shortening cycle (Horita et al., 1996; Wilson et al., 2004).

Subjects

Ten adolescent male football players (age 15.8 ± 1.47 years, height 1.66 ± 0.05 m, body weight 59.6 ± 10.7 kg, training age 3 ± 1.94 years, body mass index 21.37 ± 3.44 kg/m2) in a team competing in the Bitlis 1st Amateur Group B in the 2019/20 season volunteered for the research. The subjects declared that they would participate in the research by signing the "Informed Voluntary Consent Form for Participants". The subjects were informed about the purpose of the research and the warm-up routines applied. During the research process, it was recommended that the athletes not do any sports activities other than their warm-up routines and continue their daily eating habits without applying any special nutrition program. At the beginning of the study, the physical characteristics of all athletes were measured and recorded. The physical properties of the subjects are given in Table 1.

Table 1. Descriptive Characteristics of the Participants (mean ± standard deviation).

Variables	n	mean ±SD
Age (years)	10	15,8 ± 1,47
Height (m)	10	1,66 ± 0,05
Body weight (kg)	10	59,6 ± 10,70
Training age (years)	10	3 ± 1,94
Body mass index (kg/m^2)	10	21,37 ± 3,44

Procedures

Height and body weight measurement protocols: The heights of the subjects participating in the study were determined with the help of a meter fixed to the wall and a wooden rod. The height of the athletes was recorded in cm by measuring them barefoot, with the heels of their feet adjacent, while holding their breath with a rod placed on the head while in anatomical posture. The body weights of the subjects were measured with an electronic scale (Arçelik Slimo) with an accuracy of ±0.1 kg, only wearing shorts and a T-shirt, and recorded in kg.

Performance Tests

In anaerobic power measurements; Vertical jump test was used for lower body power and medicine ball throw test was used for upper body power measurement. The agility of the athletes was also examined with the "T-drill test". All tests are described in

Table 2.

Table 2. Performance Tests and Their Description.

Tests	Description
Vertical jump	In this measurement, the distance between the height that the person can reach while standing and the point they can touch by jumping was measured in term of meters (Cicioğlu et al., 1996). Then, using the power calculation of the subjects and their body weights, anaerobic power calculation in kg.m/s was made with the following formula†. The vertical jump was chosen as a measure of functional leg power. Harman et al. (1991) showed that this test is a valid and reliable test for assessing muscle power and explosive power.
Medicine ball throwing	The subject receives strength by bringing the medicine ball (3 kg) back at a fixed distance, with the feet in line, and the arms back. Then, he throws the ball forward with both hands with maximal power. Each subject makes two shots and the best result is recorded in term of meters (Cicioğlu et al., 1996). Throwing the medicine ball was chosen as a measure of total body power. Stockbrugger and Haennel (2001) showed that this test is a valid and reliable test for assessing total body movement pattern and general athletic ability and explosive power.
T-drill	Three cones are spaced 5 m apart in a straight line, while the fourth cone is placed 5 m from the middle cone to form a "T" (McMillian et al., 2006). The stopwatch was started as soon as the subject left point A. Subjects touch the cones at all points, running straight from point A to B, from B to C with lateral steps, from there to D with lateral steps, from D to point B with lateral steps, and finally to point A with stepping backwards from B the work has been terminated. A total of 30 m was run and the measurements were recorded down to 0.01 of a second. Pauole et al. (2000) showed that this test is a valid and reliable measure in evaluating agility. To emphasize the lateral movement, the T-drill forward and backward runs are 10 m at the distance described by Pauole et al. (2000) placed more than 5 m distance.

† Metric Unit Formula: P (kg.m/s) = $\sqrt{4.9}$ x W x $\sqrt{D}$; P = Anaerobic Power; W =Body Weight (kg); D = Jump Distance (m); $\sqrt{4.9}$ = Standard (sec) (Fox et al., 1993: 658).

Protocols

Warm-up protocol

Active warm-up was used as a warm-up method. The warm-up protocol is adjusted to increase body temperature by 1-1.5 degrees without consuming energy substrates. The subjects were given a total of 10 minutes of aerobic exercise as 8 minutes of aerobic jogging and 2 minutes of jog.

Dynamic stretching protocol

The dynamic stretching protocol consists of 15 exercises, including 10 calisthenic exercises and 5 movement drills performed in a 20-meter area (Table 3). In calisthenic exercises, 10 repetitions of each movement were performed and 5-10 seconds of rest was given between movements. In moving exercises, 1 repetition of each movement (round trip) was performed. 5-10 seconds rest between departure and return, 10-15 seconds between movements. Each stretch is done in a slow to moderate rhythm. The total duration of the dynamic stretching protocol was set to 10 minutes.

Table 3. Dynamic Stretching Exercises.

Exercises	Execution
	Calisthenic exercises
Bend and reach	Open legs shoulder-width apart and raise hands straight into the air. Then bend the knees slightly and extend the hands towards the heels. Return to the starting position in a slow rhythm (trapezius, rectus abdominis, latissimus dorsi).
Rear lunge and reach	Start with hands on hips. Take a step back. Return to the starting position in one motion. Repeat with the opposite leg. Keep most of the weight on the forefoot. Dive progressively further and deeper with each repetition. Keep the abdominal muscles tight to keep them in a stable trunk. Perform in a slow rhythm (hamstrings, calf muscles).
Turn and reach	Stand with legs spread out to the sides at shoulder level. Turn back to the furthest point with the arms as if swinging the golf club backwards. Pause with the pelvis facing forward. The arms should be directed forwards and backwards. Keep the abdominal muscles tight to keep them in a stable trunk. Return to the starting position, then repeat on the other side. Perform in a slow rhythm (latissimus dorsi, oblique muscles).
Squat	Start with hands on hips. Squat down until thighs are parallel to the floor (or pain threshold). Keep the heels on the ground. For balancing, the arms should be raised to shoulder level (quadriceps, hamstrings, gluteus maximus, calf muscles).
Rower	Start in the supine position, lift a few inches off the floor with the chin slightly tucked close to the chest. In one move, get into a sitting position, bend the knees to stabilize the feet, and bring the arms parallel to the floor (trapezius, rectus abdominis, latissimus dorsi).
Power jump	Begin with arms on hips and feet, knees and hips aligned vertically. Squat down with arms down and reach toward floor, keeping back straight, raise arms into air as you jump vertically upwards from squat position. Return to the starting position (hamstrings, quadriceps, calf muscles).
Prone row	Begin in the prone position with the arms up and a few inches off the floor, slightly lifting the chest and bringing the hands back to shoulder level as if rowing. Maintain abdominal muscle tension throughout the exercise. Hands and elbows remain parallel to the ground at all times. Keep the neck in a neutral position (trapezius, latissimus dorsi, rectus abdominis, external obliques, musculus iliopsoas).
Push-up	In the starting position, prone on the floor with hands directly at shoulder level or slightly wider. Elbows are straight but not locked. The abdomen and body are kept in line with the thighs. Do not exceed the body where the upper arms are parallel to the floor. Do it at a moderate to fast rhythm (pectorals, deltoids, triceps, serratus anterior).
Windmill	In a relatively wide stance with arms outstretched and feet slightly open at shoulder level, bend forward with the right hand to reach the left foot and rotate the body to the left. Return to the starting position, then repeat on the opposite side. Keep arms in opposite directions. Avoid excessive bending of the spine (rectus abdominis, obliques).
Diagonal lunge and reach	Push arms to the sides. Move forward diagonally to the left while simultaneously lowering the hands on the lower leg. Return to the starting position in one motion. Repeat to the right. Keep the foot of the forward leg forward, not in the direction of the lunge. Keep your body straight and your head upright. Do not let the knee of the forward leg go beyond the toes or be lateral to the foot (quadriceps, gluteus, hamstrings.).

Table 4. (continued).

Exercises	Execution
	Movement drills
Verticals	Run forward on feet, raise knees to waist level and lie down straightly. Use strong arm motion to support the movement. Hands should go over waist to chin level with a bend of approximately 90 degrees at all elbows. With these drills, the legs should not swing backwards (quadriceps, hamstrings, gluteus muscles, calf muscles).
Laterals	Step sideways, slightly rising and bringing hind leg to front leg. Quickly jump to the side and squat with feet shoulder-width apart. Always place it facing the same direction, with the first 25 meters moving to the left and the second 25 meters to the right (gracilis, adductors).
Crossovers	Put the trailer leg in front of the guide leg first and move in the direction of travel to return to the starting position. Then get the track foot behind the guide foot and move in the driving direction to return to the starting position. Repeat with the same row until the 25-yard stop. Always look in the same direction so that the movement of the first 25 meters moves to the left and the movement of the second 25 meters to the right (gluteus, gracilis, adductors).
Skip	Press and then jump, landing on the same leg, then repeat the same movement with the opposite leg. Use strong arm motion to support the movement. Hands should go over waist to chin level with a bend of approximately 90 degrees at all elbows. When the right leg moves forward, the left arm swings forward and the right arm is at the back. When the left leg is forward, the right arm swings forward and the left arm is at the back (quadriceps, hamstrings, gluteus muscles, calf muscles).
Shuttle sprint	25 m run to the line at a moderate pace. As you approach the line, slow down the movement, making a quarter turn clockwise, place the left foot parallel to the line, and crouch or bend to touch the ground on the line. Return to the starting line by turning counterclockwise to touch the floor with the right hand. 25 meters line and gradually increase (quadriceps, hamstrings, gluteus muscles, calf muscles).

Static stretching protocol

The static stretching protocol consists of 8 movements (Table 5). Each stretching movement was performed at a slow to moderate rhythm, stretching for 15 seconds. 5-10 seconds rest between movements. The total duration of the static stretching protocol was set to 10 minutes.

Table 5. Static stretching exercises.

Exercises	Execution
Overhead arm pull	Raise right arm and place right hand behind head. Grasp under the right elbow with your left hand and pull the trunk to the left, leaning to the left. Repeat the same movement on the opposite side (triceps brachii, obliques, latissimus dorsi, quadratus lumborum).
Turn and reach	Stand with arms extended to the sides at shoulder level. Twist the trunk to the left while keeping the hips forward to bring the arms forward and back. Keep the hips and abdominal muscles tight to prevent pelvic rotation. The head and eyes remain facing forward. Just hold for 10-15 seconds to avoid shoulder fatigue. Repeat in the opposite direction (pectoralis major, trapezius, latismus dorsi, biceps brachii).
Rear lunge and reach	Start with hands on hips. Take a step back as hands reach into the air at the same time. Stretch your arms in the opposite direction of your back step (ex: we stretch our right leg to the left when we step back). Return to the starting position in one motion. Repeat with opposite leg. Keep most of the weight on the forefoot. Keep the abdominal muscles tight to keep them in a stable trunk (quadriceps, abdominals, gluteus, hamstrings, hip flexors).
Hamstring stretch	Take a step forward with the left leg and bend at the waist to reach towards the left foot. Both knees are slightly bent and arms are straight on either side of the forward leg. The trunk remains in a neutral position with a flat head. Repeat on the opposite side (hamstring erector spinae, calf).
Calf stretch	Extend the left foot half a step forward and place the heel on the floor with the toes pointing up. Bend forward and grasp the sides of the left foot with both hands. Gradually straighten the knee of the left foot and pull the heel of the foot back towards the point of resistance and hold. Repeat the same movement on the opposite side (calf muscles).
Quadriceps stretch	Catch your right ankle or foot. Pull the right heel toward the buttocks and behind the buttocks. The right hip can be extended further with the pressure of the left foot. Repeat on the opposite side. Do not pull the heel strongly against the hip, especially if there is discomfort in the knee joint. In this case, get a useful stretch by allowing the knee to straighten slightly and pull towards the back of the thigh (Quadriceps).
Posterior hip stretch	In supine position, cross right ankle over left thigh. Grasp the right knee with both hands and pull it towards the left shoulder while pulling the left knee towards the chest. Repeat on the opposite side (Gluteus maximus, hamstrings, latissimus dorsi, erector spinae).
Trunk flexion/extension stretch	Part 1: In supine position, reach forward with arms at sides, chin close to chest. The head remains passively bent. Part 2: In a prone position, reach back with chin in air, arms at sides. The thighs and pelvis are flat on the floor. Relax the back and abdominal muscles as you shift body weight through straight arms. Feet point back (Rectus abdominis, pectoralis major, obliques).

Statistical Analysis

The statistic of this study was performed using One-Way Analysis of Variance (ANOVA) to determine whether the three-group variable differed between the groups in terms of performance test results. On the other hand, Tukey HSD test, which is one of the Post Hoc multiple comparison methods, was used to determine whether there was a significant difference between which groups in terms of performance test results.

All statistical operations were analyzed using the SPSS 22.0 package program and the significance level was taken as 0.05.

Findings

Test results in terms of stretching type variable of the subjects participating in the study, T-drill test 8.59 ± 0.26 sec, medicine ball throwing test 4.45 ± 1.01 m, anaerobic power test 86.4 ± 20.3 kgm/ sec; T-drill test 8.86 ± 0.32 sec, medicine ball throw test 4.57 ± 0.92 m, anaerobic power test 85.9 ± 20.8 kgm/sec in static stretching group; In the dynamic stretching group, the T-drill test was 8.30 ± 0.44 sec, the medicine ball throwing test was 4.86 ± 1.21 m, and the anaerobic power test was 91.1 ± 21.1 kgm/sec. The analysis results of the test results of the groups are shown in Table 6.

Table 6. Data on T-drill, anaerobic power test scores, ANOVA and Tukey HSD multiple comparison results in terms of stretching type variable of the subjects participating in the study (mean ± standard deviation).

		T-drill test (sec)	Medicine ball throwing test (cm)	Vertical jump test (kgm/sec)
Group	**n**	**mean ± SD**	**mean ± SD**	**mean ± SD**
Warm-up	10	8,59 ± 0,26	4,45 ± 1,01	86,4 ± 20,3
Warm-up + Static	10	8,86 ± 0,32	4,57 ± 0,92	85,9 ± 20,8
Warm-up + Dynamic	10	8,30 ± 0,44*	4,86 ± 1,21	91,1 ± 21,1
p		**,005***	**,685**	**,828**

*p<,05 Different according to the warm-up+static stretching group.

According to the variance analysis results of the subjects participating in the study, the medicine ball throwing scores of the adolescent male football players did not show a significant difference according to the stretching type variable. In other words, the effects of different stretching types on medicine ball throwing test scores were found to be similar. As a result of the analysis of the anaerobic power test, no significant difference was found between the groups. This finding can be interpreted as the effect of different stretching types on anaerobic power test scores is similar.

Contrary to other performance tests, a significant difference was found in the analysis results of the T-drill test according to the stretching type variable of male soccer players in adolescence (p<.05). According to the results of the Tukey HSD multiple comparison test performed to determine between which groups there were significant differences, there was a significant difference between dynamic stretching (8.30 ± 0.44 sec) and static stretching (8.86 ± 0.32 sec) in favor of dynamic stretching scores (p<.05) was found. This finding shows that the effect of dynamic stretching on T-drill test scores is more positive.

Discussion

In this study, we compared the acute effects of static and dynamic stretching on the power and agility of adolescent football players from their sportive performance. In the study, a p<.05 significant difference was found in agility performance in favor of dynamic warm-up type scores between dynamic warm-up type (8.30 ± 0.44 sec) and static warm-up type (8.86 ± 0.32 sec). Dynamic stretching has been found to positively affect agility. Similar studies on the effect of static and dynamic stretching exercises on agility were examined in the literature.

Unlike our study, Little et al. (2006) conducted their research on professional football players. Despite the difference in physical age and training age, agility performance results show parallelism with our study. In the study of Van Gelder et al. (2011), which is similar to our study but with different age groups, it has been observed that university students have a positive increase in 505 agility test results after dynamic stretching exercise compared to static stretching. In the study conducted by Amiri-Khorasani et al. (2010) on professional football players, an additional group of experiments in which static and dynamic stretching exercises were performed in combination, in addition to the same stretching groups, participated in the experiment. It was found that static warm-up did not have a detrimental effect on illinois agility test performance when combined with dynamic warm-up for professional football players, but when compared with the dynamic stretching group, the most effective exercise in preparation for agility performance during warm-up was dynamic stretching exercises. Chatzopoulos et al. (2014), in their study on female high school athletes, concluded that dynamic stretching is more suitable than static stretching for activities that require balance, agility and movement time of the upper extremities. In another study (McMillian et al., 2006), the effect of dynamic stretching exercises on agility performance on students aged 18-24 from the United States Military Academy club sports was in similar with our study, while different results were obtained in its positive effect on power performance. Dynamic stretching is an active contraction process and its benefits to the achieved performance; The rehearsal of movements that can increase the sensitivity of nerve receptors and increase nerve conduction velocity is facilitated motor control through increased blood flow, elevated core or peripheral temperature. It is suggested that it can increase performance as nerve impulses encourage potential muscle contractions to be faster and stronger (Shellock et al., 1985). In the related study, the reason why the effect of dynamic stretching on power differs from this study is thought to be due to the fact that the developmental stages of adolescents are still continuing. Amiri-Khorasani et al. (2013) investigated the acute effects of static, fixed dynamic and dynamic dynamic stretching exercises on power and agility on 19 university football players. According to the results of the study, the vertical jump and illinois agility test results were found to be higher in the warm-up + fixed dynamic stretching group than in the other groups. On the other hand, it was found that it caused a negative effect on the vertical jump performance in the warm-up + static stretching group.

Jordan et al. (2012) compared static and PNF stretching on U14 young football players in terms of Balsom agility test performance applied with a soccer ball. As a result of the research, it was found that static stretching did not affect agility performance and a common conclusion was reached with this study. Avloniti et al. (2016), on the other hand, concluded that static stretching applied at different times (10, 15, 20, 30, 40 and 60 seconds) does not affect agility performance. Herman et al. (2008) investigated the chronic effects of static and dynamic stretching exercises applied for four weeks on 20 active wrestling athletes on performance. As a result of the research, it was found that static stretching did not affect strength, power, endurance, speed and agility performances. Dynamic stretching was found to improve strength by 11%, power by 4%, speed, endurance by 2.4% and agility by 2%. Dynamic stretching has improved endurance and agility performance both in comparison to static stretching and in itself.

In this study, medicine ball throwing and vertical jump scores did not show a significant difference according to the warm-up type variable. Vertical jump score averages (warm-up group 86.4 ± 20.3 kgm/sec, static warm-up group 85.9 ± 20.8 kgm/sec, dynamic warm-up group 91.1 ± 21.1 kgm/sec) in dynamic warm-up group Although it is higher, the level of significance is greater than 0.05. In the literature, studies related to the effect of static and dynamic stretching exercises on power and which have parallel results with our study are mentioned below. For example, Unick et al. (2005) examined the acute effects of static and ballistic stretching on vertical jump on 16 trained women (age 19.2 ± 1.0 years) playing in the NCAA (National Collegiate Athletic Association) Division III women's basketball team. They investigated whether the power changed 15, 30 minutes after stretching. As a result of the research, it was revealed that stretching exercises and duration had no effect on power performance. In another similar study (Power et al., 2004), the effect of acute static stretching on strength and power performances was investigated on 12 university students. As a result of the research, static stretching provided a significant increase in flexibility by 6%, while it significantly decreased isometric strength by 9.5%. Explosive power, on the other hand, showed insignificant decreases between 2% and 5.4%. Little et al. (2006) concluded that static and dynamic stretching did not affect vertical jump performance on 18 professional male football players. In their study, Behara et al. (2017) looked at the acute effects of deep tissue roller rolling and dynamic stretching on muscle strength, power and flexibility in 14 attacking football players aged 18-24 playing in the NCAA Division I league. As a result of the study, hip ROM values of both exercise groups increased significantly, while power and strength performances were not affected. Faigenbaum et al. (2006) in their study investigating the effect of static stretching, dynamic stretching and combined static + dynamic stretching exercises on 30 athletes (26 men, 4 women) on power, concluded that static stretching affects power negatively, while dynamic stretching and combined static + dynamic stretching do not. The reason for the decrease in strength and power production in relation to static stretching has been attributed to the alteration of visco-elastic properties, which has been suggested to cause a decrease in the stiffness of the muscle tendon unit (Avela et al., 1999; Kokkonen et al., 1998). In contrast (Knudson et al., 2001) argue that these changes are due to acute neural inhibition, resulting in an increase in autogenic inhibition that reduces the neural excitation of the muscle and leads to a decrease in muscle activation.

In the literature review, there are studies suggesting that this study has an effect contrary to the results. For example, Jaggers et al. (2008) investigated the effects of acute dynamic and ballistic stretching exercises on vertical jump performance on 20 university students (10 males, 10 females) aged 21-34 years. As a result of the research, it was determined that there was no difference between the control group and the ballistic stretching group, but it was found that dynamic stretching increased the power compared to the control group. In another study, the acute effect of static and dynamic stretching of the lower extremities on power and EMG (electromyographic) activity in 11 healthy men, mean age 21, who regularly compete in competitive university sports (football, hockey, athletics, squash and cricket). As a result of the comparisons, it was found that static stretching negatively affected vertical jump height (4.2%), while dynamic stretching increased vertical jump height (4.25%) compared to static stretching (Hough et al., 2009). Unlike this study, in some studies, when the muscle or muscle groups included in the measurement in terms of measurement method and technique are examined from different joint angles, it has been found that dynamic stretching increases the power significantly compared to static stretching (Manoel et al. 2008; Yamaguchi et al., 2007).

Conclusion

As a result, there was no significant difference between the groups in the vertical jump and medicine ball throwing test results. According to T-drill agility test results, a significant difference $p<.05$ was found between dynamic warm-up and static warm-up in favor of dynamic warm-up scores. In the agility test results of our study, similar results were obtained with the relevant literature for adolescent athletes. When the literature is examined, there are studies on the effect of stretching on power performance, as well as studies that reached similar results with this study, as well as studies that reached a contrary conclusion. It is thought that this is due to differences such as the physical condition, physical age and training age of the experimental groups.

In sports branches where agility is at the forefront, dynamic stretching exercises may be preferred by adolescent athletes before training/competition instead of acutely static stretching.

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