DOI 10.26773/smj.210934

ORIGINAL SCIENTIFIC PAPER

Health Benefits of Balance Exercises in Sport

Rút Lenková[1]

[1]University of Presov, Faculty of Sports, Department of Sports Kinanthropology, Presov, Slovakia

Abstract

The research was focused on the development of a deep stabilization system of female handball players by applying balance exercises. The premise was to reduce the number of injuries in the context of the development of the bodily core. The study involved 17 first-league female handball players (N=17 females, age 16.1±1.89 years; weight: 54.9±3.85 kg, height: 1.66±0.03 m, BMI: 20.34±1.41 kg/m2). Following the assessment of the condition of the deep stabilization system, designed intervention programs was designed for core development. Female handball players completed 12 training units with balance equipment. The effects of the balance exercises on injury incidence were assessed comparing the number of injuries during the season and after its completion. Evaluation of the effectiveness of balance exercises revealed the development of the deep stabilization system ($p<0.05$). The injury reduction in the context of the core development was not statistically significant. There was a significant reduction in the number of injuries with a loss of time greater than seven days ($p<0.05$). This study raised the awareness of its participants about understanding the relationship between the deep stabilization system level and injury prevention.

Keywords: *sport games, handball, core training, body building, injury prevention*

Introduction

Sports injuries are a common and unfortunate aspect of participating in an athlete's sports career. If injuries are not treated properly, they affect the athletes' performance and can prevent them from competing. They can also have long-term devastating effects on the body, not only physically but also mentally.

Fear of re-injury, so-called kinesiophobia is defined as an excessive, irrational fear of physical activity and activity resulting from a sense of vulnerability to painful or repetitive injury (Flanigan, 2013). Filbay, Crossley and Ackerman (2016) state that some athletes being afraid of re-injury avoided complex activities and others completely gave up sporting activities.

Several studies focusing on injuries in sport indicate that most injuries happen in team sports. In sport games, 50% of injuries occurred when in contact with another player and 50% after a foul. 80% of players complain of health problems associated with sports. Players most often experience pain as a result of injury to various parts of the body, e.g. to the lumbar spine – 26%, ankle – 22%, knee – 17%, thigh – 14%, cervical spine – 11%, and shoulder – 10%. The authors Kisser and Bauer (2012) conducted a study on the mapping of sports injuries in the European Union. They found that 40% sports injuries requiring hospital treatment occur in team ball games.

In the study named "The Burden of Sport Injuries in the European Union", they introduce the mechanisms of injuries in team ball games. The main injury mechanisms in handball include contact with a moving object (ball), falls, tripping, a bad jump landing, and excessive load (Fuller et al., 2006).

Most expert studies on handball injuries focus on monitoring acute time-loss, as chronic injuries to players are more difficult to track and minor injuries are not recorded at all. In the case of injuries to handball players, the part of the body that is injured is monitored, and whether injuries occurred during a training or match, after contact with an opponent or without contact. Interesting are the findings related to the dependence of the number of injuries on the playing position of the handball player. Handball players most often suffer injuries to the head (15.3%) and upper and lower extremities (22.5%). Most injuries affect the lower extremities regardless of age and gender. The most common types of injuries are

Correspondence:

r. Lenková
University of Presov, Faculty of Sports, Department of Sports Kinanthropology, 17. Novembra 15, 080 01 Presov, Slovakia
E-mail: rut.lenkova@unipo.sk

sprains, contusions, and damaged ligaments (Wedderkopp, Kaltoft, Lundgaard, Rosendahl, & Froberg, 1999; Myklebus, 2010, Luig, & Henke, 2011).

In handball, 35.2% of injuries occur most often after contact with players, 24.6% in jumping or impact after jumping, 13.7% in running, 10.4% in cranks and 14.5% in falls (Myklebust et al., 2003).

Contactless injuries are generally more serious than contact injuries: almost 90% of the rupture of the anterior cruciate ligament occurred without contact with an opponent or teammate (Myklebus, 2013). Seil, Rupp, Tempelhof and Kohn (1998) state that significantly more contact injuries occur during the match than during training. The highest proportion of contact injuries (71 – 92%) occurs during top competitions such as the World Championships, the European Championships or the Olympic Games (Langevoort, Myklebust, Dvorak, & Junge, 2007). The risk of injury also depends on the player's position. In general, players are more at risk of injury in attack than in defence. Attacking clutches suffer the most injuries, followed by attacking pivotmen and players defending in the middle of the defence (Luig & Henke, 2010).

Bliven and Anderson (2013) reviewed existing professional publications in the field of nuclear stability training as a prevention of sports injury and proposed prevention programs. As a result of their research, multilateral programs are needed to reduce injury rates, which include strength, endurance, balance/posture, and neuromuscular control of the nucleus and lower limb. Soomro et al. (2014) carried out a systematic review of published prevention programs in sport (football, basketball and handball) and verified their effectiveness.

Junge, Runge, Juul-Kristensen and Wedderkopp (2016) from the Institute of Physical Education at Odense University in Denmark, in response to the high number of injuries to young female handball players in Denmark (40.7 injuries per 1,000 hours of wrestling), suggested to include a structured warm-up at the beginning of the training unit lasting 10–15 minutes as prevention of knee and ankle injuries. They found out that in the intervention group (n=111), the number of injuries during the match was reduced by 80% and during training by 70% compared to the control group (n=126), which trained without a structured warm-up. In the next phase, Junge et al. (2016) tried to find out whether the implication of balance exercises in a structured warm-up influenced the reduction of the number of injuries. The group that did not use training on a balance platform had 2.6 times higher number of traumatic injuries and approximately 3 times higher number of injuries during training and as well as during the match. In addition, the group using the balance platform had significantly less serious injuries. This proved that the implication of balance exercises in a structured warm-up reduces the number and severity of injuries in handball.

One of the components of prevention programs to reduce injuries in handball is core training (Luig & Henke, 2010, Myklebust et al., 2003; Myklebust, Skjølberg, & Bahr, 2013). Several studies suggest that deficiencies in the stabilization of the body's core and load-bearing muscles may be related to lower limb function and injury (Bliven & Anderson, 2013), which are the most common handball injuries.

Injuries can also be affected by the overall functional state of the body, muscle imbalance, fatigue and, of course, contact with a teammate (Boržiková & Mihalčin, 2015; Kokinda et al., 2018). The findings were a research problem in our study. The aim was to develop a deep stabilization system in the context of reducing the number of handball injuries. We formulated two hypotheses. H1 – The application of the intervention training program will increase the level of the deep stabilization system of female handball players. H2 – Increasing the level of the deep stabilization system of female handball players will have the effect on reducing the number of injuries.

Methods

Participants

The sample consisted of non-randomly sampled female handball players, meeting the requirements defined in advance – female handball players playing the highest competition, age classification in the category of younger and older adolescents, the opportunity to include an intervention program to develop a deep stabilization system in their training plan (Table 1). Based on these conditions, younger and older adolescents, who in the 2018/2019 and 2019/2020 seasons played in the 1st league of younger adolescents and in the 1st league of older adolescents, were selected.

Table 1. Sample characteristics

Variables	Minimum	Maximum	Mean	Standard deviation
Age [years]	14	18	16.1	1.5
Height [cm]	155	178	166.9	6.0
Mass [kg]	49	82	61.2	9.4
Training history [years]	5	8	6.89	1.2
Occurrence of injuries [june 2019]	0.0	2.2	1.57	0.2

Design and procedures

The participants were familiar with the measuring design and signed the written informed consents. Before the measurements were taken, anthropometric data was collected – weight (Electronic scale, Amboss, New York, USA), height (Antropometr A 213, Trystom, Olomouc, Czech Republic), age, and foot size, and a survey was administered among the participants. The study has been approved by the Ethics Committee of the University of Presov, Slovakia (approval no.: 3/2021).

Pre-test

The testing of the state of the deep stabilization system of the players took place at the beginning of the summer training period using field motor tests, which are often used in clinical practice: T1/endurance test of spinal extensors, T2/endurance test of abdominal muscles – flexors, modified by Biering-Sorenson test, T3/side-plank endurance test.

Intervention

The exercises to mobilize and strengthen the muscles of the deep stabilization system with balance equipment were the intervention factor. The intervention lasted for six weeks, with session duration of 55 minutes twice a week. Warm-up exercises included mobilization exercises of the deep stabilization system lasting 10 minutes. The main part of the training unit included 15 exercises divided into 3 series of 5 exercises. The number of repetitions of the exercise depended on the type of the exercise. There was a break of 10 seconds between the exercises in the sets and a break of 30 seconds between the series. The subjects performed the exercises under our supervision and control of the trainer (Figure 1). During the exercises, emphasis was placed on the technically correct performance of the exercises, with a neutral position of the spine, with the correct position of the pelvis and the correct way of breathing during the exercise.

FIGURE 1. Example of exercises during the intervention

Post-test

After completing the intervention program, the post-test was administered in the same way and under the same conditions as the pre-test.

Statistical analysis

We used statistical characteristics of the central tendency position, variance and mathematical-statistical methods to process the obtained data. We used M–mean, SD– standard deviation, max – maximum value, min – minimum value for the calculation. To determine the significance of the differences between the results of the state of the deep stabilization system at pre-test and post-test, we used a paired t-test for dependent variables using the program psppire.exe with an accuracy of 3 decimal places.

Results

Analysis of the development of a deep stabilization system in relation to the used intervention program

Sample characteristics are presented in Table 1. The evaluation of the overall results of the effectiveness of a deep stabilization system development showed statistically significant

Table 2. Analysis of the results of the development of a deep stabilization system

	M [s]	SD	Min [s]	Max [s]	T	P
T1						
Pre-test	49.76	20.08	19	83	5.91	0.00
Post-test	79.94	30.69	35	144		
T2						
Pre-test	44.00	19.67	24.00	96.00	8.06	0.00
Post-test	59.88	18.27	38.00	108.00		
T3						
Pre-test	38.12	11.05	21.00	62.00	8.13	0.00
Post-test	56.76	17.33	34.00	98.00		

Note: T1 - endurance test of spinal extensors; T2 - abdominal muscle endurance test; T3 - strength endurance test (lateral plank); M - mean; SD - standard deviation; T -t value; P - value differences ($p<0.05$) caused by the action of the experimental factor (Table 2). In terms of improving the level of spinal extensors (T1), the endurance of abdominal muscle strength – flexors (T2) and improving the level of muscle strength securing the lateral plank (T3), we state that significant statistical differences were found in all three motor tests. Based on the average of values, it can be stated that the balance exercises included in the training process had a positive effect on the development of a deep stabilization system.

Analysis of the number of injuries

To determine whether the improvement of the state of a deep stabilization system affected the reduction in the number of injuries, we recorded the number of injuries and information on injuries using the questionnaire during the same time period before and after the intervention.

The research hypothesis that the reduction in the number of injuries depends on the context of the development of a deep stabilization system has not been confirmed (Table 3).

Table 3. Number of acute injuries to body parts at pre-test and post-test

Injured body part	Number of injuries	
	Pre-test Regular season October 2018 - May 2021	Post-test Regular season October 2019 - May 2020
hip	1	0
ankle	6	4
head	4	3
spine	4	3
knee	5	3
hand	4	6
sum	24	19
T	-0.35	
P	0.741	

It is in accordance with the published results of a survey by Bliven and Anderson (2013), who argue that multilateral programs are needed to reduce injury rates.

The success of the handball injury prevention program is seen not only in the reduction of the total number of injuries, but especially in the reduced number of serious injuries that require a long recovery period during which the athlete is out of training and competing (Table 4).

Table 4. Time loss in acute injuries before and after the intervention

Loss of time in the acute injury	Number of acute injuries	
	Pre-test	Post-test
from 4 to 7 days	4	10
less than a month	13	7
more than a month	3	2
T	-2.55	
P	0.027	

We observed in which body parts the number of injuries decreased with more than 7 days loss of training (Table 5).

Table 5. Number of acute injuries to body parts in relation to time loss

body parts	from 4 to 7 days		less than a month		more than a month	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
hip	0	0	1	0	0	0
ankle	0	0	5	3	0	1
head	1	3	1	0	1	0
spine	2	3	1	0	0	0
knee	0	0	3	2	1	1
hand	1	4	2	2	1	0

Discussion

The primary goal of the study was to identify the possibilities of developing a deep stabilization system of female handball players in the training process. To examine the effect of balance exercises applied in the form of an intervention program, it was necessary to motivate and educate the coach as well as the players.

The first of the motor tests of the deep stabilization system was the spinal extensor test (T1) modified by the Biering-Sorenson test. At post-test, we found out that the effect of our intervention program improved the strength of the spinal extensors and we achieved an increase in the average value by 30.18 s. Based on the measured values, we state that the female handball player with the lowest level of spinal extensors, despite an improvement of 16 s, did not even reach the pre-test mean value of the handball players. The percentage improvement (ratio of the difference between post-test and pre-test to the pre-test value) was on average 67.2%±42.8%, indicating significant differences in improvement among female handball players.

The second test measuring abdominal muscular endurance – flexors (T2) demonstrated improvement of all players after completing the intervention training program. Every player stayed in the desired position for a longer time during the post-test than the during the pre-test. The percentage improvement – the ratio of the difference between the post-test and post-test value – was on average 42.7%±27.4% indicating significant differences in improvement among tested subjects. Both the percentage improvement in the T2 test and the variance of the values are lower than in the T1 test.

The third test diagnosing the condition of the deep stabilization system was the lateral plank test (T3, lateral plank). After completing the intervention training program, each player's level of muscle strength providing for the lateral plank improved. Each player held the lateral plank position for a longer time at post-test compared with the pre-test. The percentage improvement – the ratio of the difference between post-test and post-test to pre-test– in the side-plank test averaged 50.4%±21.1%, indicating significant differences in improvement among test subjects, although the lowest variance of values was noted in this test.

Regarding the reduction in the number of injuries, we did not notice statistically significant differences after the completion of our proposed intervention program. We did not find a correlation between the monitored variables, such as the development of a deep stabilization system in the context of reducing the number of injuries. In the post-intervention period, the total number of injuries decreased by 5.2% from the number of injuries before the intervention.

After the intervention, the number of injuries to the upper limbs increased, but the number of injuries to the ankle, knee and hip decreased. We expected such a result based on several published studies (Bliven & Anderson, 2013; Junge et al., 2016). Their results pointed out that deficiencies in the stabilization of the body's core may be related to the function of the lower limbs and their injuries, which are the most common injuries of handball players.

The loss of time is directly proportional to the severity of the injury, i.e. the period of time after the injury during which the player is unable to participate fully in the training or match. By analysing the structure of injuries before and after the intervention, we found that after the intervention, the number of less serious injuries increased by 250% with a loss of time of 4 to 7 days. Importantly, the number of injuries with a loss of time of more than a month and the number of injuries with a loss of more than seven days and less than one month decreased. Based on the above, it can be stated that the number of injuries decreased significantly with a loss of time longer than seven, which is a decrease of 66% from the original number, which was statistically significant.

Limitations and future directions

The study was focused on linking biomechanical and kinesiological research. It is recommended to examine the effects of balance exercises from the orthopaedic and traumatological point of view, which would provide a better overview of the causal relationships between the monitored variables. Regarding the study's reservations - in the social field, the sample size may not be sufficient in terms of representativeness. The future research should work with a larger sample. It would also be useful to explore the motivation and approach to the application of specific exercises in sports training and other sports.

Conclusion

To test hypothesis H1 "Application of the intervention training program will increase the level of the deep stabilization system of handball players", we compared the results at pre-test before the intervention program and post-test after the intervention program for the development of a deep stabilization system. Based on the results, we state that each of the three tests from the test battery selected by us showed a statistically significant improvement in the condition of the deep stabilization system, which was reflected in an increase in endurance in the tested positions. Based on these results, we can confirm the validity of the established hypothesis.

At the same time, based on the test results from the used test battery, we can state that the improvement of the state of the deep stabilization system occurred in all players and was observed in each of the three tests used. Based on theoretical background, we expect that this side result of this study– the development of a deep stabilization system of players, had a positive impact on improving health, physical abilities and sports performance of handball players.

Comparing the number of injuries of individual body parts in the monitored periods before and after the intervention program for the development of a deep stabilization system, we found that reducing the number of injuries is not statistically significant and therefore we must reject hypothesis H2 "Increasing the level of the deep stabilization system of handball players will have the influence on decreasing the number of injuries". This is in line with the results published by Bliven and Anderson (2013), who, based on an analysis of published sports injury prevention programs, reported that deficiencies in stabilizing the body's core and load-bearing muscles may be related to lower limb function and injury. Based on this, we could assume that the development of core stabilization will cause a reduction in the number of lower limb injuries. This was confirmed in the monitored injuries.

There was a statistically significant reduction in the number of injuries with a loss of time of more than seven days, which decreased from 26 in the monitored part of the years 2018/2019 before the intervention to 9 in 2019/2020 after the intervention. This reduction was especially appreciated by the players and their coach. If we have contributed to this reduction to some extent by including the intervention programwe have created in the summer training of players, then we can consider this as a positive contribution of our experiment.

The deep stabilization system should be active at all times, only then people can ensure proper and painless posture and also the correct involvement of muscles during exercise, which each of our training makes more effective (Peate, Bates, Lunda, Francis, & Bellamy, 2007).

Acknowledgements
This study was conducted within the project VEGA*1/0573/18 "The function of trunk muscle strength in the development of athletic performance and injury prevention".*

Conflict of Interest
The author declare that there is no conflict of interest.

Received: 25 December 2020 | **Accepted:** 11 February 2021 | **Published:** 01 September 2021

References
Bliven,K.H.,&Anderson,B.E.(2013).CoreStabilityTrainingforInjuryPrevention. *Sports Health, 5*(6), 514-522. doi: 10.1177/1941738113481200

Boržíková, I. & Mihalčín J. (2015). Functional disorders of the muscles and joints of young soccer players as a result of improper training load. *Scientific review of physical culture*, 5(4), 5–11.

Flanigan, D. C. (2013). Fear of reinjury (kinesiophobia) and persistent knee symptoms are common factors for lack of return to sport after anterior cruciate ligament reconstruction. *Arthroscopy*, *29*(8), 1322-1329.

Filbay, S. R., Crossley, K. M., & Ackerman, I. N. (2016). Activity preferences, lifestyle modifications and re-injury fears influence longer-term quality of life in people with knee symptoms following anterior cruciate ligament reconstruction: a qualitative study. *Journal of physiotherapy*, *62*(2), 103–110. https://doi.org/10.1016/j.jphys.2016.02.011

Fuller, C. W., Ekstrand, J., Junge, A., Andersen, T. E., Bahr, R., Dvorak, J., Hägglund, M., McCrory, P., & Meeuwisse, W. H. (2006). Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine*, *16*(2), 97–106. https://doi.org/10.1097/00042752-200603000-00003

Junge, T., Runge, L., Juul-Kristensen, B., & Wedderkopp, N. (2016). Risk Factors for Knee Injuries in Children 8 to 15 Years: The CHAMPS Study DK. *Medicine and science in sports and exercise*, *48*(4), 655–662. https://doi.org/10.1249/MSS.0000000000000814

Kisser, R., & Bauer, R. (2012). *The burden of sports injuries in the European Union. Research report D2h of the project "Safety in Sports".* Austrian Road Safety Board (Kuratorium für Verkehrssicherheit).

Kokinda, M., Jesensky, M., Kandrac, R., Kicura, D., Turek, M., & Chovanova, E. (2018). Examination of age-related core stability and dynamic balance in hockey players. *Sport Mont, 16*(2), 21-26. doi: 10.26773/smj.180604

Langevoort, G., Myklebust, G., Dvorak, J., & Junge, A. (2007). Handball Injuries during major international tournaments. *Scandinavian Journal of Medicine & Science in Sports*, *17*(4), 400-407. doi: 10.1111/j.1600-0838.2006.00587.x

Luig, P., & Henke, T. (2010). *Safety in Sports.* Best Injury Prevention Measures and Implementation Strategies in Handball and Basketball (D5). RuhrUniversityBochum.

Luig, P., & Henke, T. (2011). Acute Injuries in Handball. Science and AnalyticalExpertise in Handball (Scientific and Practical Approaches). *European Handball Federation*, 78-83.

Myklebust, G., Engebretsen, L., Braekken, I. H., Skjølberg, A., Olsen, O. E., & Bahr, R. (2003). Prevention of anterior cruciate ligament injuries in female team handball players: a prospective intervention study over three seasons. *Clinical journal of sport medicine: official journal of the Canadian Academy of Sport Medicine*, *13*(2), 71–78. https://doi.org/10.1097/00042752-200303000-00002

Myklebust, G. (2010). Team Handball. *Epidemiology of Injury in OlympicSports*, 260-276.

Myklebust, G., Skjølberg, A., & Bahr, R. (2013). ACL injury incidence in female handball 10 years after the Norwegian ACL prevention study: important lessons learned. *British journal of sports medicine*, *47*(8), 476–479. https://doi.org/10.1136/bjsports-2012-091862

Peate, W. F., Bates, G., Lunda, K., Francis, S., & Bellamy, K. (2007). Core strength: a new model for injury prediction and prevention. *Journal of occupational medicine and toxicology (London, England)*, *2*, 3. https://doi.org/10.1186/1745-6673-2-3

Seil, R., Rupp, S., Tempelhof, S., & Kohn, D. (1998). Sports Injuries in Team Handball. *The American Journal of Sports Medicine*, *26*(5), 681–687. https://doi.org/10.1177/03635465980260051401

Soomro, N., Sanders, R., Hackett, D., Terrance, J., Freeston, J., Blanch, P., & Maclennan, M. (2015). Efficacy of injury prevention programs in adolescent sports: A Systematic Review. *Journal of Science and Medicine in Sport*, *44*(9), 2415-24. https://doi.org/10.1016/j.jsams.2014.11.389

Wedderkopp, N., Kaltoft, M., Lundgaard, B., Rosendahl, M., & Froberg, K. (1999). Prevention of injuries in young female players in European team handball. A prospective intervention study. *Scandinavian journal of medicine & science in sports*, *9*(1), 41–47. https://doi.org/10.1111/j.1600-0838.1999.tb00205.x