

ACCEPTED: December 2018

PUBLISHED ONLINE: January 2019

DOI: 10.5960/dzsm.2018.358

Schneider J, Wiegand Y, Braumann K-M, Wollesen B. Functional and motor deficits in youth soccer athletes – an explorative, quasi-experimental study. Dtsch Z Sportmed. 2019; 70: 14-20.

# Functional and Motor Deficits in Youth Soccer Athletes – An Explorative, Quasi-Experimental Study

*Funktionelle und motorische Defizite bei Nachwuchsfußballspielern – eine explorative, quasi-experimentelle Studie*

1. UNIVERSITÄT HAMBURG, *Institut für Bewegungswissenschaft, Hamburg, Germany*

## Summary

- ▶ **Background & Aim:** Little is known about functional and motor deficits in male soccer players aged 9-13 and the impact they have on sports injuries and the prevention thereof. Hence, this study assesses functional and motor deficits in the aforementioned population and investigates the effects of an individualized training intervention on functional and motor deficits.
- ▶ **Methods:** This explorative, quasi-experimental study design allocated male soccer players (9-13 years) (n=48) into intervention group (n=23) and control group (n=25). Both groups performed the functional movement screen, toe touch test and weight-bearing lunge test pre-intervention and post-intervention. The intervention group performed a 12-week multimodal training intervention twice per week for 10-15 minutes. The total score of the functional movement screen and the results of the toe touch test and weight-bearing lunge test served as the outcome parameters.
- ▶ **Results:** We identified a variety of functional and motor deficits. All participants improved their total score of the functional movement screen ( $F(1)=32.27$ ;  $p<0.001$ ;  $\eta^2=0.42$ ), toe touch test ( $F(1)=10.48$ ;  $p<0.01$ ;  $\eta^2=0.19$ ) and weight-bearing lunge test ( $F(1)=8.46$ ;  $p<0.01$ ;  $\eta^2=0.16$ ). The intervention group showed higher improvements for the functional movement screen ( $F(1,46)=4.46$ ;  $p<0.05$ ;  $\eta^2=0.09$ ), toe touch test ( $F(1,46)=10.48$ ;  $p<0.01$ ;  $\eta^2=0.19$ ) and weight-bearing lunge test ( $F(1,46)=8.46$ ;  $p<0.01$ ;  $\eta^2=0.16$ ).
- ▶ **Conclusion:** A 12-week multimodal training intervention can effectively reduce functional and motor deficits identified in male soccer players aged 9-13 years and might serve as a helpful tool in injury prevention.

## Zusammenfassung

- ▶ **Hintergrund und Ziel:** Bislang befassten sich nur wenige Studien mit funktionellen und motorischen Defiziten und deren Konsequenzen auf das spätere Verletzungsrisiko bei Fußballspielern im Alter von 9-13 Jahren. Ziel dieser Studie war die Identifikation möglicher motorischer Defizite und die Erprobung einer individualisierten Intervention zur Reduktion erfasster motorischer Defizite
- ▶ **Methode:** Die explorative, quasi-experimentelle Studie untersuchte männliche Fußballathleten (9-13 Jahre; N=48) mit einer Interventions- (n=23) und einer Kontrollgruppe (n=25). Die Untersuchungen umfassten den Functional Movement Screen Test (FMS), den Toe Touch Test und den Weight-Bearing Lunge Test im Pre-Post-Design. Die Interventionsgruppe absolvierte ein 12-wöchiges individualisiertes Trainingsprogramm zwei Mal pro Woche für 10-15 Minuten. Der Summenscore des FMS sowie die Ergebnisse des Toe Touch Test und Weight-Bearing Lunge Test wurde als Outcome-Parameter analysiert.
- ▶ **Ergebnisse:** Es konnte eine Vielzahl an motorischen Defiziten identifiziert werden. Alle Fußballer verbesserten den Gesamtscore des FMS ( $F(1)=32.27$ ;  $p<0.001$ ;  $\eta^2=0.42$ ), Toe Touch Test ( $F(1)=10.48$ ;  $p<0.01$ ;  $\eta^2=0.19$ ) und Weight-Bearing Lunge Test ( $F(1)=8.46$ ;  $p<0.01$ ;  $\eta^2=0.16$ ). Die Interventionsgruppe zeigte hierbei höhere Verbesserungen für den FMS ( $F(1,46)=4.46$ ;  $p<0.05$ ;  $\eta^2=0.09$ ), den Toe Touch Test ( $F(1,46)=10.48$ ;  $p<0.01$ ;  $\eta^2=0.19$ ) und den Weight-Bearing Lunge Test ( $F(1,46)=8.46$ ;  $p<0.01$ ;  $\eta^2=0.16$ ).
- ▶ **Fazit:** Eine 12-wöchige individualisierte Trainingsintervention kann effektiv funktionelle und motorische Defizite bei männlichen Nachwuchsfußballern im Alter von 9-13 Jahren reduzieren und somit ein hilfreiches Instrument zur Verletzungsprophylaxe darstellen.

## KEY WORDS:

Motor Deficits, Youth Soccer, Injury Prevention, Flexibility, Training Intervention

## SCHLÜSSELWÖRTER:

Motorische Defizite, Nachwuchsfußball, Verletzungsprävention, Beweglichkeit, Trainingsintervention

## Introduction

Soccer is characterized by quick accessions, short sprints, abrupt stops, changes of direction, jumps, landings, kicks and duels (29). Over the last decades, imposed by sports-related demands, physical stress and strains on the body for soccer athletes have risen (4, 28) and injury prevention has gained more importance.

Many soccer specific injuries occur already in younger athletes and children under the age of 15 are especially at risk (27, 21). A recent meta-analysis (14) has shown a correlation of increasing training loads and increasing injury rates across a variety of sports, thus calling for effective injury prevention strategies at times of increasing training loads, for example in



Article incorporates the Creative Commons Attribution – Non Commercial License.  
<https://creativecommons.org/licenses/by-nc-sa/4.0/>



Scan QR Code and read article online.

## CORRESPONDING ADDRESS:

Dr. Bettina Wollesen  
 Universität Hamburg  
 Institut für Bewegungswissenschaft  
 Arbeitsbereich Bewegungs- und Trainingswissenschaft  
 Mollerstr. 10, 20148 Hamburg, Germany  
 ✉: [bettina.wollesen@uni-hamburg.de](mailto:bettina.wollesen@uni-hamburg.de)

young athletes. Age has been identified as another important risk factor for injury incident in soccer players (2). Moreover, a variety of studies discussed flexibility as a risk factor for sports injury (24), but findings are still inconsistent.

Previous studies examined possible prevention strategies (9, 26) in subjects aged 14-18 years. In a meta-analysis, Rössler et al. (26) concluded that exercise-based injury prevention programs are effective in reducing injury rates in youth sports. However, there is a considerable lack of data for children (under 14 years), boys (representing only 12.7 % of the overall study population), and for individual sports (26).

Overall, little is known about deficits in motor performance in male soccer players under the age of 14. Hence, the aim of this study is to identify functional deficits in male child soccer players.

We hypothesize that male child soccer players already show functional and motor deficits. Furthermore, we explore the effect of an individualized multimodal training intervention on functional deficits in male child soccer players. We hypothesize that a multimodal training intervention affects previously identified functional deficits. Thus, this study tries to give new insight for a prevention strategy of sports injuries in soccer players under the age of 14.

## Methods

### Design

This explorative, quasi-experimental study design compared two groups of male child soccer players (INT, n=23 & CON, n=25). Subjects performed a pretest and posttest to assess functional deficits. In-between both tests, the intervention group (INT) completed an individualized multimodal training intervention as a warm up at the beginning of their regular soccer practice. The control group (CON) only performed both tests and participated in their regular soccer practice. The study period was February to June 2017.

### Subjects

Male subjects free of any pain or injuries were recruited via personal contacts with the FC St. Pauli soccer club in Hamburg (U10, U11, U12 and U13).

Subjects were divided into an intervention group (INT n=23, U11 & U13) and a control group (CON n=25, U10 & U12) in correspondence with their coaching staff. Subjects (n=3) who suffered an injury or missed a training session were excluded from the study.

## Anamnesis

Anamnesis of anthropometric data occur prior to the testing procedure commonly used at the FC St. Pauli. The leg length was measured from the floor to the anterior superior iliac spine, tibia length was measured from the floor to the proximal end of the tibial tuberosity. The hand length was measured from the wrist crease to the tip of the third digit. Participants were asked about their dominant hand and leg. n=40 participants had the right leg as the dominant leg and n=8 (INT n=7; CON n=1) the left.

### Instruments

The functional movement screen (FMS) (7, 12, 13) was performed to test flexibility, coordination and asymmetries (19). The FMS in its entirety, including judgement criteria, has been well described (12,13,20). Additionally, participants performed the

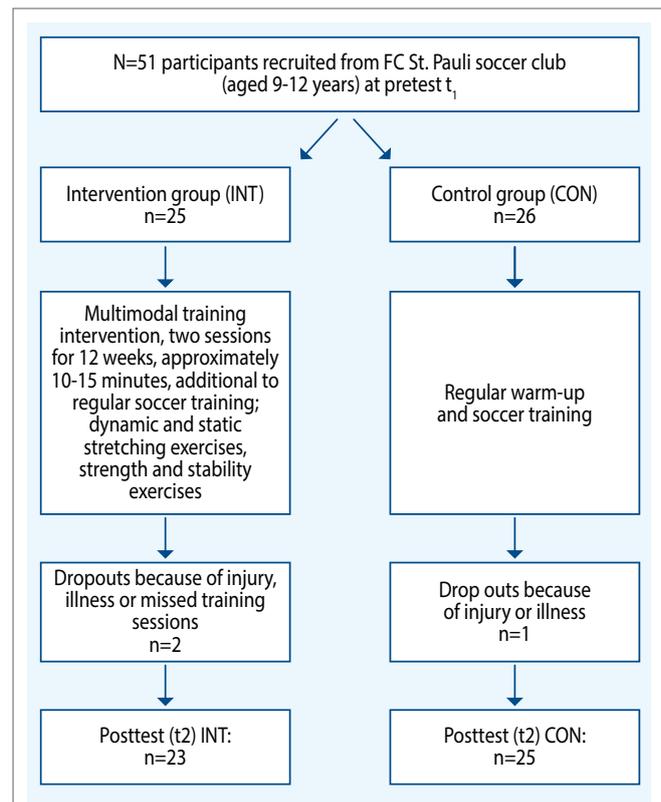


Figure 1

Study flow. INT=intervention group; CON=control group.

toe touch test (TT) to assess the flexibility of the hamstrings and the spinal erectors (3) and the weight-bearing lunge test (WBLT) to assess the dorsiflexion of the ankle joint. It is characterized by robust quality criteria (11, 16).

### Testing procedure

The FMS, TT and WBLT are common practice in the club and part of the general performance assessment. Therefore, the participants and their parents were acquainted with the testing procedure of the study. For the TT, participants received a standardized instruction to completely extend their knees while standing and then touch their toes with their hands. The test was judged as "positive" or as "negative", depending on the ability to touch the toes with the hands. For the WBLT (both sides) participants were instructed to place one of their feet ten centimeters away from a wall, with their heel on the ground, toes pointing towards the wall. They were then asked to bend the corresponding knee forward against the wall, without elevating the heel. The test was either judged as "positive" or as "negative", depending on the ability to touch the wall with the knee, without elevating the heel.

Subjects were introduced and familiarized with the tests. Oral consent to the procedure of the tests was given by all subjects followed by the anamnesis. During a standardized procedure the correct execution of all seven movements of the FMS was demonstrated and participants completed the FMS. Afterwards TT and the WBLT were performed.

### Intervention

INT received an individualized 12-week multimodal training intervention, twice per week for 10-15 minutes as a warm-up at the beginning of the regular soccer practice instead of their usual warm-up routine. According to individual functional deficits analyzed by pre-test data, an individualized training

Table 1

Anthropometric data of the sample at t1, t2 and the functional deficits identified by FMS, TT or WBLT in the sample at t1, number of participants per group with the specific deficits and corresponding exercises employed in the multimodal training intervention. Given are means and standard deviation. INT=Intervention group; CON=Control group; t1=day of the pretest; t2=day of the posttest; BMI=Body Mass Index; cm=centimeter; kg=kilogram; FMS=Functional Movement Screen; TT=Toe Touch Test; WBLT=Weight Bearing Lunge-Test; sec=seconds.

ANTHROPOMETRIC DATA	INT (N=23)		CON (N=25)		TOTAL (N=48)	
	T1	T2	T1	T2	T1	T2
Body height/cm	154.44	156.00	151.35	152.48	148.52	149.24
	±9.13	±9.11	±10.22	±10.57	±10.52	±10.96
Body mass/kg	42.71	43.05	40.98	41.62	39.38	39.61
	±5.96	±6.08	±7.41	±7.56	±8.33	±8.50
Age/years	11.44	11.87	10.83	11.33	10.28	10.84
	±0.73	±0.87	±1.16	±1.16	±1.21	±1.18
BMI	17.85	17.64	17.76	17.62	17.67	17.61
	±1.39	±1.50	±1.72	±1.80	±2.00	±2.07
NUMBER OF IDENTIFIED FUNCTIONAL DEFICITS	CORRESPONDING EXERCISES FOR INT GROUP				SETS X REPETITIONS OR DURATION/SEC	
1) Limited hip and knee flexion & ankle dorsiflexion	n=20		n=19	Ankle Mobility	2 x 10 repetitions	
				Calf Stretch	2 x 10 repetitions	
				Assisted Squat	2 x 10 repetitions	
2) Poor stance-leg stability of ankle, knee and hip and poor balance	n=15		n=16	Balance Stick	2 x 8 repetitions	
3) Limited hip extension and hip mobility	n=18		n=17	Hamstring Kicks	2 x 10 repetitions	
				Balance Stick	2 x 8 repetitions	
4) Limited rectus femoris flexibility	n=10		n=7	Lying Quad Stretch	2 x 20/sec	
				Kneeling Rectus Femoris Stretch	2 x 20/sec	
5) Limited functional hamstring flexibility	n=16		n=14	Balance Stick	2 x 8 repetitions	
				Hamstring Kicks	2 x 10 repetitions	
				Toe Touch Progression	2 x 10 repetitions	
6) Limited shoulder, scapular and thoracic spine mobility	n=16		n=13	Quadruped T-Spine Rotation	2 x 10 repetitions	
7) Limited abdominal and trunk stability	n=8		n=13	Mountain Climber	2 x 10 repetitions	
				Shoulder Taps	2 x 10 repetitions	
				Shrimp	2 x 10 repetitions	

program was given to every subject of INT. A score of “one” or “zero” in any of the seven movements that compose the FMS as well as a “negative” TT or WBLT constituted a functional deficit. The exercises of the training programs were chosen by the researchers and aimed to improve the specific functional deficits of every subject (cf. table 2). The exercises were chosen from a catalogue of exercises, which is being used at the FC St. Pauli to improve functional deficits identified with the FMS. Every exercise in this catalogue corresponds to a specific movement of the FMS. Every participant was given six exercises including dynamic and static stretching exercises, strength exercises, exercises to improve stability of the musculoskeletal system and exercises to improve balance. Two sets of eight or ten repetitions were performed of all dynamic stretching exercises.

Exercises were demonstrated to the participants before the intervention. The training intervention was supervised by the trainers of the teams U11 and U13. CON did not change their warm-up, which consisted of jogging and running exercises. Both, INT and CON, completed their regular soccer practice three times per week for 90 minutes.

### Statistical Analysis

All statistics were evaluated using SPSS 22 (IBM statistics Armonk, NY). To analyze differences between the groups for the pre-post conditions, variance (two-way ANOVA; group\*time) was computed for each variable of the anthropometric data. A Wilcoxon-Test was conducted to describe functional deficits (i.e. FMS, TT, WBLT) in the pre-post condition. Group differences were calculated with

Table 2

Results of the pretest and posttest. Given are means and standard deviation. INT=intervention group; CON=control group; t1=pretest; t2=posttest; DS=Deep Squat; HS=Hurdle Step; ILL=In-Line Lunge; SM=Shoulder Mobility; ASLR=Active Straight Leg Raise; TSPU=Trunk Stability Push-Up; RS=Rotary Stability; TT=Toe Touch Test; WBLT=Weight-Bearing Lunge Test.

		DS	HS RIGHT	HS LEFT	ILL RIGHT	ILL LEFT	SM RIGHT	SM LEFT	ASLR RIGHT	ASLR LEFT	TSPU	RS RIGHT	RS LEFT	TOTAL SCORE	TT	WBLT RIGHT	WBLT LEFT
INT (n=23)	t1	1.65	1.78	1.74	1.78	1.87	2.57	2.35	2.04	1.91	2.26	1.87	1.87	13.26	0.39	0.26	0.26
		±0.49	±0.52	±0.45	±0.52	±0.54	±0.90	±0.95	±0.71	±0.67	±0.62	±0.34	±0.34	±1.84	±0.50	±0.45	±0.45
	t2	1.74	2.04	2.00	1.91	1.96	2.74	2.57	2.13	2.00	2.26	1.87	1.87	14.30	0.67	0.26	0.52
		±0.45	±0.21	±0.00	±0.42	±0.48	±0.45	±0.51	±0.63	±0.60	±0.62	±0.34	±0.34	±1.43	±0.47	±0.45	±0.51
CON (n=25)	t1	1.72	1.56	1.64	1.92	1.92	2.44	2.20	1.80	1.80	2.00	1.72	1.80	12.68	0.52	0.48	0.60
		±0.54	±0.65	±0.64	±0.57	±0.57	±0.82	±0.87	±0.65	±0.65	±0.87	±0.46	±0.41	±2.61	±0.51	±0.51	±0.50
	t2	1.72	1.60	1.76	1.92	2.00	2.52	2.36	1.84	1.80	2.04	1.72	1.80	13.16	0.52	0.48	0.60
		±0.54	±0.65	±0.60	±0.57	±0.50	±0.65	±0.64	±0.63	±0.65	±0.87	±0.46	±0.41	±2.44	±0.51	±0.51	±0.50

the Mann-Whitney-U-Test. Significance level was set as  $\alpha=0.05$ ; normal distribution was tested using the Kolmogorov-Smirnow test. Effect sizes are given as partial eta squares ( $\eta^2$ ). Bonferroni correction was applied to post hoc comparisons.

## Results

### Anthropometric Data of the Sample

All participants of the intervention and control group increased their body height ( $F(1,46)=56.77$ ;  $p<0.001$ ;  $\eta^2=0.55$ ) and body mass ( $F(1,46)=11.55$ ;  $p<0.01$ ;  $\eta^2=0.20$ ). As reported in table 1 the intervention group showed a greater growth (+1.56 cm) than the control group (+1.04 cm) from pre to post testing ( $F(1,46)=7.77$ ;  $p<0.01$ ;  $\eta^2=0.14$ ).

### Functional Deficits of the Youth Athletes

Table 1 shows the functional deficits identified in INT and CON at the t1. In both groups limited hip and knee flexion and limited ankle dorsiflexion was observed most frequently. The difference between INT (n=8) and CON (n=13) was greatest concerning limited abdominal and trunk stability. Greater differences for the INT were observed for limited rectus femoris flexibility, limited functional hamstring flexibility and limited shoulder, scapular and thoracic spine mobility.

### Effects of the Training Intervention on Motor Performance

As reported in table 2 all participants improved their performance; the changes in the different exercises are presented in table 2.

The Mann-Whitney-U-Test revealed significant group differences for the HS left and right at post-testing (left:  $Z=-3.09$ ,  $p=0.002$ ; right:  $Z=-2.02$ ,  $p=0.044$ ). Moreover, the WBLT differed between the groups at baseline testing ( $Z=-2.34$ ,  $p=0.019$ ). The Wilcoxon-Test showed significant improvements for both groups from pre- to post-testing (INT:  $Z=-3.23$ ,  $p=0.001$ ; CON:  $Z=-2.97$ ,  $p=0.003$ ). In addition, the intervention group improved in the HS left and right (left:  $Z=-2.45$ ,  $p=0.0012$ ; right:  $Z=-2.45$ ,  $p=0.001$ ), the TT ( $Z=-2.47$ ;  $p=0.008$ ) and the ankle mobility ( $Z=-2.50$ ;  $p=0.001$ ).

## Discussion

The aim of this explorative study was to identify functional deficits in male child soccer players (aged 9 - 13 years) to implement injury prevention strategies into training sessions for soccer players under the age of 14 years.

Our hypothesis that male child soccer players already show functional deficits was verified; all participants of the study showed functional deficits in all observed variables (cf. Table 1).

These functional deficits are a risk for a variety of injuries like joint and ligament injuries, contusions, muscle and tendon injuries as well as fractures and bone injuries (27). Therefore, this study affirmatively confirms previous results highlighting reduced hip ROM and hamstring flexibility in professional soccer players aged 19-36 years (10). Imbalances between quadriceps and hamstring strength have been observed in youth soccer players aged 13 - 16 years (17). We hypothesized that because of adaptation to unilateral load in the absence of compensatory training these asymmetrical strength ratios can be already observed in soccer players aged 9 - 13 years. This hypothesis is supported by the data of the TT. Additionally, the functional deficits observed in this study were similar to those observed by Agre & Baxter (1), who identified deficient hip abduction, hip flexion, hip extension and ankle dorsiflexion in male collegiate soccer players. However, we recognize that sport-specific adaptations of the musculoskeletal system may also be beneficial and required for maximum performance.

Additionally, serious concerns remain regarding the validity and explanatory power of some of our results concerning the FMS. According to Kolodziej & Jaitner (2018), the risk of injury increases with a FMS score of lower than 14 while a lack of the trunk stability and rotary stability are the main predictors for injuries (20). However, as we examined children, the results of this paper might not be transferable into this age group. For our study, the limited ankle dorsiflexion and limited functional hamstring flexibility can be regarded as the key findings of this study, since those were also confirmed by the WBLT and TT. The training routine could reduce the functional and motor deficits in the posttest despite of limited exercise selection. Therefore, the results of this study demonstrate how little equipment and effort is needed to yield improvements and potentially

prevent sports injuries, as also shown by Imai et al. (18), who prevented injuries with three additional stability exercises in the warm-up program. When possible, stretching exercises were performed as dynamic stretching exercises, because it has been shown to increase flexibility and positively impact performance (5, 6, 22).

Because the multimodal training program is not time consuming it could easily be implemented into the warm-up phase of soccer practice twice a week for 10-15 minutes. The youth athletes executed the training intervention correctly, adhered to the program and effects were already seen after three months. However, future research needs to identify a minimum frequency per week and a minimum total duration.

The intervention group gained higher positive effects for the main outcome parameters of the FMS, the TT and the WBLT compared to the control group (cf. table 2). One might argue that the observed effects are a result of the increased body height (e.g. improvements of the Hurdle Step). However, the intervention group showed higher improvements for all tests in comparison to the control group, which underlines the benefits of the intervention. The results of the TT indicate improved flexibility of the hamstrings. Limited hamstring flexibility is associated with a higher risk of muscle strain, sprain or overuse injury (8, 30). However, research has not yet concluded why limited hamstring flexibility produces a higher risk of injury (8), but its injury-preventive effects are well documented. It is proposed that the mechanism for decreased range of motion in joints is a decreased neural stretch tolerance rather than a viscoelastic accommodation of the muscle-tendon unit (23). Bradley & Portas (8) suggest that some players with greater ROM may have a "flexibility reserve", which reduces tension on the hip and knee flexors during high speed movements such as sprinting, thus protecting these players against injury. The intervention was effective at increasing participants hamstring flexibility and thereby may reduce their risk of sports injury. The results of the WBLT indicate improved ankle dorsiflexion ROM in the study population. Greater ankle dorsiflexion ROM was associated with greater knee-flexion and smaller ground reaction forces during landing (15), which are both risk factors for anterior cruciate ligament injuries, indicating that increasing ankle dorsiflexion ROM may be an effective tool to reduce the risk of anterior cruciate ligament injuries (15). Additionally, poor ankle dorsiflexion ROM is a good indicator of ankle sprain (25). By increasing ankle dorsiflexion ROM in the intervention group, the intervention employed in this study may reduce participants risk of anterior cruciate ligament injury or ankle sprain.

In conclusion, we confirmed our hypothesis that a multimodal training intervention influences previously identified functional and motor deficits in soccer players aged 9-13 years.

## Limitations

Due to practical reasons, a randomization of the subjects into an intervention and a control group was not possible. This may have led to a group bias in terms of age during a critical pubertal phase in favour of the intervention group, possibly confounding the results. The distribution followed in coordination with the coaching staff and investigators were not blinded to group allocation. The circumstances which caused the research to take place during the common practice might have led to the limitations of study design. Another limitation of the study is that the assessed functional and motor deficits are based on the judgement criteria of the researcher.

## Conclusion

This study assessed a range of functional and motor deficits in male soccer players aged 9 - 13 years. In the population of this study, the intervention had positive effects on the previously assessed functional and motor deficits. To our best knowledge, this is the second study to investigate the effects of a multimodal training intervention in male soccer players under the age of 14 years. The additional benefit of this study results out of the fact that the multimodal training intervention used in this study employed different kinds of exercises than the first study did. Future research needs to assess the effects of such multimodal training interventions on the incidence of injury during practice and match to conduct effective injury prevention strategies for soccer players under the age of 14 years. Nonetheless, the results of this study lead to the recommendation to implement specific motor testing and individualized multimodal training programs into regular soccer practice of players under the age of 14 years. ■

## Compliance with Ethical Guidelines

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the Helsinki declaration and its later amendments or comparable ethical standards.

## Conflict of Interest

*The corresponding author and two of his co-authors declare that they have no competing interests. It is hereby declared that one of the co-authors of this study is part of the coaching staff of the FC St. Pauli.*

## References

- (1) **AGRE JC, BAXTER TL.** Musculoskeletal profile of male collegiate soccer players. *Arch Phys Med Rehabil.* 1987; 68: 147-150.
- (2) **ARNASON A, SIGURDSSON SB, GUDMUNDSSON A, HOLME I, ENGBRETTSEN L, BAHR R.** Risk factors for injuries in football. *Am J Sports Med.* 2004; 32: 5-16. doi:10.1177/0363546503258912
- (3) **AYALA F, SAINZ DE BARANDA P, DE STE CROIX M, SANTONJA F.** Reproducibility and criterion-related validity of the sit and reach test and toe touch test for estimating hamstring flexibility in recreationally active young adults. *Phys Ther Sport.* 2012; 13: 219-226. doi:10.1016/j.ptsp.2011.11.001
- (4) **BANGSBO J, MOHR M, KRUSTRUP P.** Physical and metabolic demands of training and match-play in the elite football player. *J Sports Sci.* 2006; 24: 665-674. doi:10.1080/02640410500482529
- (5) **BEHM DG, BLAZEVIČ AJ, KAY AD, MCHUGH M.** Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: A systematic review. *Appl Physiol Nutr Metab.* 2016; 41: 1-11. doi:10.1139/apnm-2015-0235
- (6) **BEHM DG, CHAOUACHI A.** A review of the acute effects of static and dynamic stretching on performance. *Eur J Appl Physiol.* 2011; 111: 2633-2651. doi:10.1007/s00421-011-1879-2
- (7) **BONAZZA NA, SMUIN D, ONKS CA, SILVIS ML, DHAWAN A.** Reliability, Validity, and Injury Predictive Value of the Functional Movement Screen. *Am J Sports Med.* 2017; 45: 725-732. doi:10.1177/0363546516641937
- (8) **BRADLEY PS, PORTAS MD.** The relationship between preseason range of motion and muscle strain injury in elite soccer players. *J Strength Cond Res.* 2007; 21: 1155-1159. doi:10.1519/R-20416.1
- (9) **BRINK MS, VISSCHER C, ARENDS S, ZWERVER J, POST WJ, LEMMINK KA.** Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. *Br J Sports Med.* 2010; 44: 809-815. doi:10.1136/bjism.2009.069476
- (10) **CHIN MK, LO YS, LI CT, SO CH.** Physiological profiles of Hong Kong elite soccer players. *Br J Sports Med.* 1992; 26: 262-266. doi:10.1136/bjism.26.4.262
- (11) **CHISHOLM MD, BIRMINGHAM TB, BROWN J, MACDERMID J, CHESWORTH BM.** Reliability and validity of a weight-bearing measure of ankle dorsiflexion range of motion. *Physiother Can.* 2012; 64: 347-355. doi:10.3138/ptc.2011-41
- (12) **COOK G, BURTON L, HOOGENBOOM BJ, VOIGHT M.** Functional movement screening: the use of fundamental movements as an assessment of function - part 2. *Int J Sports Phys Ther.* 2014; 9: 549-563.
- (13) **COOK G, BURTON L, HOOGENBOOM BJ, VOIGHT M.** Functional movement screening: the use of fundamental movements as an assessment of function - part 1. *Int J Sports Phys Ther.* 2014; 9: 396-409.
- (14) **DREW MK, FINCH CF.** The Relationship Between Training Load and Injury, Illness and Soreness: A Systematic and Literature Review. *Sports Med.* 2016; 46: 861-883. doi:10.1007/s40279-015-0459-8
- (15) **FONG C-M, BLACKBURN JT, NORCROSS MF, MCGRATH M, PADUA DA.** Ankle-dorsiflexion range of motion and landing biomechanics. *J Athl Train.* 2011; 46: 5-10. doi:10.4085/1062-6050-46.1.5
- (16) **HALL EA, DOCHERTY CL.** Validity of clinical outcome measures to evaluate ankle range of motion during the weight-bearing lunge test. *J Sci Med Sport.* 2017; 20: 618-621. doi:10.1016/j.jsams.2016.11.001
- (17) **IGA J, GEORGE K, LEES A, REILLY T.** Cross-sectional investigation of indices of isokinetic leg strength in youth soccer players and untrained individuals. *Scand J Med Sci Sports.* 2009; 19: 714-719. doi:10.1111/j.1600-0838.2008.00822.x
- (18) **IMAI A, IMAI T, IIZUKA S, KANEOKA K.** A Trunk Stabilization Exercise Warm-up May Reduce Ankle Injuries in Junior Soccer Players. *Int J Sports Med.* 2018; 39: 270-274. doi:10.1055/s-0044-100923
- (19) **KIESEL K, PLISKY P, BUTLER R.** Functional movement test scores improve following a standardized off-season intervention program in professional football players. *Scand J Med Sci Sports.* 2011; 21: 287-292. doi:10.1111/j.1600-0838.2009.01038.x
- (20) **KOLODZIEJ M, JAITNER T.** Single Functional Movement Screen items as main predictors of injury risk in amateur male soccer players. *Ger J Exerc Sport Res.* 2018; 48: 349-357. doi:10.1007/s12662-018-0515-2
- (21) **KOUTURES CG, GREGORY AJM.** Injuries in youth soccer. *Pediatrics.* 2010; 125: 410-414. doi:10.1542/peds.2009-3009
- (22) **LITTLE T, WILLIAMS AG.** Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. *J Strength Cond Res.* 2006; 20: 203-207. doi:10.1519/R-16944.1
- (23) **MAGNUSSON SP, SIMONSEN EB, AAGAARD P, SØRENSEN H, KJÆR M.** A mechanism for altered flexibility in human skeletal muscle. *J Physiol.* 1996; 497: 291-298. doi:10.1113/jphysiol.1996.sp021768
- (24) **MURPHY DF, CONNOLLY DAJ, BEYNNON BD.** Risk factors for lower extremity injury: A review of the literature. *Br J Sports Med.* 2003; 37: 13-29. doi:10.1136/bjism.37.1.13
- (25) **POPE R, HERBERT R, KIRWAN J.** Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in Army recruits. *Aust J Physiother.* 1998; 44: 165-172. doi:10.1016/S0004-9514(14)60376-7
- (26) **RÖSSLER R, DONATH L, VERHAGEN E, JUNGE A, SCHWEIZER T, FAUDE O.** Exercise-based injury prevention in child and adolescent sport: a systematic review and meta-analysis. *Sports Med.* 2014; 44: 1733-1748. doi:10.1007/s40279-014-0234-2
- (27) **RÖSSLER R, JUNGE A, CHOMIAK J, DVORAK J, FAUDE O.** Soccer Injuries in Players Aged 7 to 12 Years: A Descriptive Epidemiological Study Over 2 Seasons. *Am J Sports Med.* 2016; 44: 309-317. doi:10.1177/0363546515614816
- (28) **STØLEN T, CHAMARI K, CASTAGNA C, WISLØFF U.** Physiology of soccer: an update. *Sports Med.* 2005; 35: 501-536. doi:10.2165/00007256-200535060-00004
- (29) **WISLØFF U, HELGERUD J, HOFF J.** Strength and endurance of elite soccer players. *Med Sci Sports Exerc.* 1998; 30: 462-467. doi:10.1097/00005768-199803000-00019
- (30) **WITVROUW E, DANNEELS L, ASSELMAN P, D'HAVE T, CAMBIER D.** Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. A prospective study. *Am J Sports Med.* 2003; 31: 41-46. doi:10.1177/03635465030310011801