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EFFECTS OF SPECIFIC PROGRAMMED TRAINING ON DYNAMIC STABILIZERS OF KNEE JOINT IN ADULT AMATEUR SOCCER PLAYERS

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Original research:

Abstract
Execution in soccer depends on many different factors, including technical, tactical, biomechanical and physiological component. Unpredictable situations put soccer in group of complex sports, but, at the same time, that unpredictability increases injury risk, specially of lower limbs. The aim of this research is to determine level of quantitative changes in dynamic knee stabilizers under the influence of programmed training between initial and final testing. Sample of respondents were 18 adult amateur soccer players (Mean±SD: height 178.9±6.5 cm, weight 70.5±11.4 kg). All of them had to satisfy inclusion criteria. Dynamic knee stability was tested on isokinetic dynamometer, with angular speed of 60˚/s and 180˚/s (Biodex Isokinetic System 3). Conclusion is that implemented program can influence on knee stabilizers very positively by developing strength and left leg H:Q ratio on 60˚/s angular speed, and can be considered as a comprehensive prevention training program for soccer players. Also, influence of the program on H:Q ratio is not completely clear, since respondents had very good results in these variables even before implementing the program, so the further researches are suggested.
Keywords: soccer, isokinetic, prevention, knee

Introduction

Execution in soccer depends on many different factors, including technical, tactical, biomechanical and physiological component (Stolen et al., 2005). It is almost unreal for one soccer action to be repeated twice with exactly the same components of speed, place, direction and moment (Verheijen, 2014). That unpredictability defines soccer as a complex sport, but, at the same time, it increases injury risk, specially of lower limb.
Strength in soccer is important for injury prevention (Manolopoulos et al., 2006) and game performance (Ronnestad et al., 2011). Explosive muscular contraction, especially of knee extensors, is crucial component for sprinting ability (Downson et al., 2008). During the game, the most important motoric tasks (jump, kick, turn and sprint), are directly correlated with the neuromuscular power production capacity (Cometti et al., 2001; Suchomel et al., 2016). Professional players make from 150 to 250 explosive actions during the game (Bangsbo et al., 2006). Although players spend only 11% of playing time in sprinting, this ability highly influence quality of performance, with directly influence on ball possession quality, assisting and goal scoring (Reilly et al., 2000). Around 90% of sprints during the game takes less then 5s (Andrzejewski, 2013). For improving sprinting ability, it is recommended to perform maximal squat strength training (Styles et al., 2016).
One professional player suffers 4 to 8 injuries in 1000 minutes of playing (Ekstrand et al., 2011). In soccer, most injuries take lower limbs, and on lower limbs, most risky areas are hamstrings, knees and ankles (Quisquater et al., 2013; Suzue et al., 2014).
Variables that can give information about potential knee injury in soccer player are: hamstring/quadriceps ratio (H:Q), bilateral strength deficit and muscle weakness (Alentorn-Geli et al., 2009; Hughes, 2014). Low H:Q ratio on isokinetic testing of professional soccer players, in most cases, is noticed in players with very strong knee extensor muscle (m. quadriceps), while players with lower values of extensor's strength have recommended H:Q ratio (Bogdanis & Kalapotharakos, 2016). Since H:Q ratio can be very accurate fatigue indicator, it is recommended that H:Q ratio should be tested and trained in functional eccentric/concentric (ECC/CON) muscle contraction, rather than in traditional concentric/concentric (CON/CON) muscle contraction (Delextrat et. al, 2010).
Previous injuries in professional soccer players can significantly increase risk of same type injuries and on

same side of body (Nordstrom et al., 2014), but there are scientific evidences that previous injuries don't necessarily have to be anatomically related to other type injuries (Hagglund et al., 2013.). Low value of knee flexor peak torque (PT) on isokinetic testing after repeated sprint exercises, can identify previous hamstring injuries with 100% accuracy (Lord et al., 2018.), but can't be predictor of future injuries (Dauty et al., 2003).

Risk of musculoskeletal injuries is 16 times higher if the PT imbalance between knee joint extensors is over 10%, and that risk is 12 times higher if the PT imbalance between knee joint flexors is over 10% (Liporaci et al., 2019). Eccentric bilateral hamstring imbalance higher than 15% is a very significant predictor for hamstring injuries (Fousekis et al., 2011). Also, position in the game plays a very important role on the level of muscles imbalances, since there are statistically significant differences in isokinetic testing results between players who play in different positions (Śliwowski et al., 2017). Football players lower limbs are characterized by significant muscles asymmetries, which means individual modification of training volume and individual correction of muscles asymmetries are very desirable as a form of injury prevention (Fousekis et al., 2010). Specific programs can affect all isokinetic variables of the knee joint. Example of such programs are HarmoKnee prevention program (Daneshjoo et al., 2012; Daneshjoo et al., 2013) and FIFA 11+ prevention program (Brito et al., 2010; Daneshjoo et al., 2012; Daneshjoo et al., 2012; Daneshjoo et al., 2013; Reis et al., 2013; Talović, 2016; Lopes et al., 2019)

The aim of this research is to determine level of quantitative changes in dynamic knee stabilizers under the influence of programmed training between initial and final testing.

Methods

Sample

18 adult amateur football players (Mean±SD: height 178.9±6.5 cm, wight 70.5±11.4 kg) were sample of respondents of this study. They all compete in Third league of Bosnia and Herzegovina (amateur league). Inclusion criteria were:

1. At least 15 played games in previous season;
2. Participation in at least 70% of training sessions in previous season;
3. At least 3 years of playing experience in adult football.

All participants were registered in their clubs, and they could perform in official league matches. They, also, passed medical examination, so they were able to implement the planed program and testing intended for this research.

Variables

Dynamic knee stability was tested on isokinetic dynamometer, on angular speeds of 60˚/s and 180˚/s (Biodex Isokinetic System 3). Variables used for testing of the knee extensors (m. quadriceps) and flexors (hamstring) strength were: peak torque (PT), total work (TW), average power (AVG) and hamstring/quadriceps ratio (H:Q ratio). Both legs were tested on angular speeds of 60˚/s and 180˚/s. In total, that makes 28 isokinetic variables (14 variables on angular speeds 60˚/s and 180˚/s), that were measured two times: before and after implementation of the program (initial and final testing).

Testing procedures

One of many research's in Bosnia and Herzegovina, where isokinetic testing was represented, is PhD dissertation (Alić, 2012): Training effects of functional and motoric abilities of football players in preparation and competition period under the influence of the specific training process. The dynamic knee stabilizers testing protocol is taken from this PhD dissertation. Before every testing, hight and wight were measured to all participants. The isokinetic testing protocol was:

1. Warm up and general stretching.
2. Setting the respondents in an optimal stabilization.
3. Alignment between the joint and dynamometer rotation axis.
4. Positioning the resistance pads.
5. Verbal introduction to the concept of isokinetic exercise
6. Gravity correction.
7. Warm up at speed 60˚/s (3 submaximal, 1 maximal repetition).
8. Maximum test at testing speed 60˚/s (5 repetitions).
9. Rest (30 seconds).
10. Testing of other limb at same angular speed (60˚/s).
11. Identical testing procedure on testing speed 180˚/s.

Data Analysis

The data obtained in this research were analyzed by software IBM SPSS v25 (IBM corp., Armonk, NY, USA). Descriptive statistics were presented as a mean values and standard deviation. The Kolmogorov-Smirnov test (KS) verified normality of data. For evaluation of the program's effects on selected variables, Paired Sample T-test was used ($p<0.05$).

Experimental program description

Training program was realized through a regular club training process (schedule of trainings, competition and free days), in preparation period of the season. All activities, except experimental program, were led by head coach of the team.

Results

After realization of the program, the increase of mean value was noted in all variables. Significant differences between initial and final testing results were noted in flexion PT on both legs and both testing speeds, flexion and extension AVG on both legs and both testing speeds, flexion and extension TW on both legs and both testing speeds and H:Q left leg ratio at 60˚/s

Table 1 Training program with volume parameters

Training	*Number of exercises*	*Exercises order Unilateral and bilateral*	*Number of series*	*Duration / repetitions*	*Rest*
1	4	Bi, Bi, Uni, Uni	2,2,2,2	8,8,8,8	30",30",30",30"
2	4	Bi, Bi, Bi, Bi	2,2,2,2	60",60",60",60"	60",60",60",60"
3	4	Bi, Uni, Bi, Bi	3,3,3,3	30",60",60",20"	30",40",40",40"
4	4	Bi, Uni, Uni, Uni	3,3,3,3	10,10,10,5	40",40",40",30"
5	3	Bi, Bi, Bi	4,4,4	60",60",60"	20",20",20"
6	5	Bi, Uni, Uni, Uni, Uni	3,3,3,3,4	20",20",20",20",20"	40",40",40",40" 30"
7	3	Uni, Uni, Uni	4,4,4	60",60",60"	25",25",25"
8	4	Bi, Uni, Uni, Bi	3,3,4,3	35",60",6 rep,25"	50", 30", 25", 30"
9	4	Uni, Uni, Bi, Bi	4,4,5,4	60",60",60",25"	30",30",60",60"
10	3	Bi, Uni, Bi	3,3,8	35",25",60"	50",60",50"
11	4	Bi, Bi, Uni, Bi	3,3,3,2	60",60",60",20"	60",60",60",60"
12	2	Uni, Bi	4,4	60",60"	70",70"
13	4	Uni, Uni, Bi, Bi	5,5,5,5	60",60",60",60"	60",60",60",60"
14	4	Uni, Uni, Uni, Bi	3,3,3,3	60",60",60",35"	75",75",75",60"
15	3	Uni, Uni, Uni	4,4,4	60",60",60",60"	90",90",90"
16	4	Bi, Uni, Uni, Bi	3,3,3,3	30",30",30",25"	45",45",45",60"
17	4	Bi, Bi, Uni, Bi	3,3,2,4	60",35",12 rep., 25"	60",60",50",60"
18	4	Bi, Bi, Uni, Bi	4,4,3,3	35",60",60",25"	50",60",60",60"
19	5	Bi, Bi, Bi, Bi	3,3,2,2,4	60",35",12",20",25"	60",50",45",45",50"
20	2	Uni, Uni	5,5	60",60"	60",60"

7 weeks were period of preparation before competition, so that was a duration of experimental program. 20 training sessions were held during this period, with frequency of 2 to 3 training sessions per week.

After initial testing, the program volume was customized. Exercises from the program were applied in warm up of every training. The accent of exercises was on lower limb, specially knee flexors and extensors, but program also included fun balance games in pairs, technical exercises with the ball, core strength exercises, etc. Body weight was used for all exercises, without additional equipment for strength training. Structure of exercises was based on parallel half-squats and squats, lunges, short sprints, jumps and post activation potentiation (jump, sprint, ball kick). The accent was on unilateral balance exercises. Progression of the volume was made by increasing exercises duration, number of repetitions and sets, or exercises specificity (more complex exercise). The general program was shown in table 1, together with volume progression.

(Mean 9.63; $p<0.02$). The biggest mean differences between two testing were noted in variables TW left and right flexion at speed 60˚/s (Mean 83.69, $p<0.01$; Mean 77.41, $p<0.01$), AVG right and left flexion at speed 180˚/s (Mean 72.86, $p<0.01$; Mean 90.64, $p<0.01$). Also, great progress was noted in some knee extension variables: TW right extension at speed 60˚/s (Mean 82.76, $p<0.01$) and AVG left extension at speed 180˚/s (Mean 72.39, $p<0.01$). Generally, 21 variables have significant difference between initial and final testing. In the remaining 7 (PT left and right extension on both testing speeds, H:Q left and right ratio on 180˚/s testing speed, and H:Q ratio on right leg at speed 60˚/s), there was not statistically significant difference, but there are some positive changes between two testing, although not on such a large scale.

Discussion

From tables 2 and 3, it is clear that statistically significant changes are noted in many tested variables. Based on mean change, the biggest changes occurred in knee flexion variables, more precisely, in flexion TW and AVG on both tested speeds. In implemented program unilateral balance exercises were most common, so the assumption is that those exercises influenced developing of flexion TW and AVG, since relation between those abilities is proven by previous research (Liu-Ambrose et al., 2003).

Statistically significant changes in extension PT on both legs and both angular speeds are not noted on final testing. One of the reasons which could lead to this kind of results is that many specific football actions activates knee extensor muscle (m. quadriceps), specially ball shooting (Scurr et al., 2011). Also, that technical element is the most significant factor of lower limbs fatigue (Feraz et al., 2012). Since quadriceps muscle, together with hip flexor and extensor, and gluteal muscles, is very active in many non-ball football actions: sprint, change of direction, jump, landing, etc. (Hanson et al., 2008), it is possible that players who were sample in this research, already had optimal level of quadriceps strength, due to constant repetition of actions of this type. Consequently, this program, which contained great number of balance exercises, and not strength exercises, didn't influence knee extensors maximal strength development.

Another interesting fact from results of testing, is that program didn't statistically influence on H:Q ration, with exception of variable H:Q ratio left leg on speed 60˚/s ($p<0.02$). H:Q ratio, which is not inside recommended values between 54 and 64 %, can be related with non-contact muscle injuries (Liporaci et al., 2019). These muscle injuries, primarily, are injuries of knee flexor muscle (hamstring). They arise as a result of maximal knee extension, and impossibilities of knee flexor muscles, as antagonists in this move, to properly control move and make deacceleration in its eccentric contraction (Croisier et al., 2008). In football, this action is actually shooting the ball, sprint, etc. So, actions which are very common in the game. Also, it is proven that greater activation of quadriceps muscle, and minor activation of hamstring and gastrocnemius during the landing action, leads to reduction of angles in knee during the flexion, so this type of landing can greatly influence reduction of knee injuries in flexion

Table 2 Results of initial and final testing on angular speed 60˚/s

Variables	Initial		Final		t	Sig. (p)	Mean	95% CI diff.	
	Mean	SD	Mean	SD				Lower	Upper
PT left extension	209.78	28.70	216.90	23.30	-1.35	.19	-7.12	-18.23	3.98
PT right extension	211.06	32.09	221.44	27.52	-2.08	.05	-10.38	-20.92	.16
PT left flexion	117.16	16.52	125.74	16.91	-2.46	.03	-8.58	-15.95	-1.22
PT right flexion	122.51	17.77	133.35	20.17	-3.68	.00	-10.84	-17.06	-4.63
AVG left extension	130.76	19.25	144.70	21.10	-3.16	.01	-13.94	-23.25	-4.63
AVG right extension	137.14	23.85	146.03	20.55	-2.56	.02	-8.89	-16.23	-1.55
AVG left flexion	83.83	12.03	95.09	12.88	-3.76	.00	-11.27	-17.58	-4.95
AVG right flexion	89.02	11.28	101.25	16.28	-5.14	.00	-12.23	-17.26	-7.21
TW left extension	499.98	95.67	569.73	82.06	-2.90	.01	-69.76	-121.06	-18.45
TW right extension	521.66	96.91	604.42	92.72	-3.45	.00	-82.76	-133.41	-32.12
TW left flexion	337.34	83.35	421.03	99.18	-2.87	.01	-83.69	-145.25	-22.14
TW right flexion	345.92	63.21	423.33	61.91	-4.37	.00	-77.41	-114.82	-40.00
H:Q ratio left	56.55	8.45	66.18	16.25	-2.60	.02	-9.63	-17.45	-1.82
H:Q ratio right	58.55	7.76	60.77	6.63	-1.38	.19	-2.22	-5.61	1.18

Table 3 Results of initial and final testing on angular speed 180˚/s

Variables	Initial		Final		t	Sig. (p)	Mean	95% CI diff.	
	Mean	SD	Mean	SD				Lower	Upper
PT left extension	137.07	24.39	146.17	17.32	-2.05	.06	-9.10	-18.46	.256
PT right extension	139.30	20.92	144.77	18.60	-1.40	.18	-5.47	-13.73	2.80
PT left flexion	90.08	9.48	99.12	10.59	-3.65	.00	-9.04	-14.28	-3.81
PT right flexion	94.05	11.82	100.90	13.72	-3.23	.00	-6.85	-11.33	-2.37
AVG left extension	231.14	44.23	254.82	32.35	-2.00	.01	-72.39	-40.35	-7.02
AVG right extension	237.85	43.53	259.53	36.56	-2.67	.02	-62.67	-38.80	-4.56
AVG left flexion	156.54	21.35	175.81	23.82	-3.92	.01	-72.86	-29.64	-8.88
AVG right flexion	160.26	24.20	180.97	29.74	-3.56	.01	-90.64	-32.98	-8.45
TW left extension	637.50	112.30	709.89	86.18	-3.53	.01	-23.68	-115.70	-29.07
TW right extension	665.55	121.79	728.22	94.96	-2.41	.03	-21.68	-117.61	-7.72
TW left flexion	460.26	54.44	533.12	53.73	-4.49	.00	-19.26	-107.14	-38.59
TW right flexion	477.88	71.65	568.52	102.10	-2.86	.01	-20.72	-157.44	-23.85
H:Q ratio left	67.03	8.85	68.33	7.31	-.71	.49	-1.31	-5.18	2.57
H:Q ratio right	68.41	9.72	69.93	6.92	-.81	.43	-1.53	-5.52	2.47

(Walsh et al., 2012). Very important information, which gives special importance to this variable, is that hamstring injury is most common injury in professional sport (Ernlund & Vieira, 2017), while in football this injury takes 37% of all injuries (Askling et al., 2013). Based on these facts, it is clear that H:Q ratio variable is very important to follow for the player, in order to perform continuously, without injuries. However, analyzing results of testing, it is notable that sample had H:Q ratio on optimal level even before of implementation of program. Therefore, observed from the aspects of needs, it was not necessary to make corrections based on the initial testing. Fact that could be more valuable is that implementation of program didn't disturb H:Q ratio, since this variable is very variable, and should be tested regularly and maintained with, mostly, eccentric hamstring exercises (Muhammad & Anup, 2018). Application of these kind of exercises, as a way of hamsting and anterior cruciate ligamentum (ACL) injury prevention, is recommended by previous research's (Salci et al., 2013; Seymore, 2015; Ernlund & Viera, 2017). Hamstring together with ACL prevents internal rotation of tibia and ligament rupture (Hanson, 2008; Pettitt & Bryson, 2002). This type of exercises were part of implemented program through hamstring activation exercises, but their influence on H:Q ratio is not completely clear, since sample had optimal value of H:Q ratio in initial testing.

Implemented program positively affected all tested variables, although some of them didn't have statistically significant change. Program is very practical, since a lot of exercises are with the ball, which makes them football-specific and interesting for the players. It doesn't take a lot of time and doesn't require any additional props, and that makes its organization and implementation much easier. Also, it gives very good results on knee dynamic stabilizers, since it improves PT, TW and AVG of hamstring on both legs and both tested angular speeds, and it also improves TW and AVG of quadriceps on both legs and both tested angular speed.

Conclusion

The aim of this research is to determine level of quantitative changes in dynamic knee stabilizers under the influence of programmed training between initial and final testing.

The specific prevention program was implemented in regular training schedule. Its duration was 2 months, 20 training sessions and was implemented in warm up phase of training, 2-3 times per week. Dynamic knee stabilizers were tested on isokinetic dynamometer, on angular speeds of 60°/s and 180°/s.

It can be concluded that implemented specific prevention program can make very positive changes on strength of dynamic knee stabilizers and H:Q ration of left leg, and can be considered as a comprehensive injury prevention program of knee joint.

Suggestion for further research's is to implement program on the sample that don't have optimal H:Q ratio, since this could present impact of the program on this group of variables more precisely, and, at the same time, could examine the need of adding isolated eccentric hamstring strength exercises in to the program.

Lack of research is non-existence of control group, which could additionally point out impact of the program on tested variables.

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