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THE ACUTE EFFECTS OF DIFFERENT WARM-UP PROTOCOLS ON SOME PERFORMANCE PARAMETERS IN U11-16 SOCCER PLAYERS

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Summary: Purpose: The purpose of the study is to examine the acute effects of different warm-up protocols on some physical performance parameters in the Under 11-16 (U11-16) category soccer players. **Material and Methods:** The participant group of the study consisted of seventy-two male soccer players who regularly train in the U11-16 category. Soccer players randomly and counterbalanced participated in the one of the warm-up protocols of FIFA 11+, HarmoKnee, Dynamic warm-up, or Mixed warm-up on non-consecutive days. After participants performed one of the protocols, their flexibility, vertical jump, 30m sprint, and agility performances were measured. Repeated measures in the ANOVA test were used to determine intra-group differences (U11-U12-U13-U14-U15-U16) and Bonferroni test was used to decide which protocol caused a significant difference.
Results: In all underage categories, FIFA 11+, HarmoKnee, and dynamic warm-up caused a significant difference in flexibility, vertical jump, 30 m sprint, and agility compared to Mixed warm-up ($p < 0.05$).
Conclusions: As a result of the study, it was shown that FIFA 11+, HarmoKnee, and dynamic warm-up protocols acutely caused a positive influence in flexibility, vertical jump, 30 m sprint, and agility in all underage categories. These three warm-up protocols may be used to prevent athletes from warm-up uniformity and monotony and support multidirectional development.

Keywords: Fifa11+; Harmoknee; Dynamic Warm-up; Countermovement Jump; Agility; Flexibility

Introductıon

A competition and training warm-up (WU) is performed to optimize neural, metabolic, and temperature-related factors of the body such as increasing contraction velocity, improving strength and power outputs and oxygen-carrying capacity (Jeffreys 2007; McGowan, Pyne, Thompson, Rattray 215). Recently soccer-specific warm-up programs have evolved to a more comprehensive style. Specifically, exercises in these protocols have been split into different named sections and categories and they do not only consider optimization of the performance but also injury prevention and long-term

development (Ayala, Calderón-López, Delgado-Gosálbez, Parra-Sánchez, Pomares-Noguera, Hernández-Sánchez et al., 2017; Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson, Byberg, 2010).

FIFA 11+ and HarmoKnee are two well-known warm-up protocols used in soccer (Balsalobre-Fernández, Glaister, Lockey 2015; Bizzini, Junge & Dvorak 2013; Daneshjoo, Mokhtar, Rahnama, 2013).

FIFA 11+ aims to standardize the warm-up of amateur soccer players while preventing injuries (Ayala, Calderón-López, Delgado-Gosálbez, Parra-Sánchez, Pomares-Noguera, Hernández-Sánchez et al. 2017; Bizzini, Junge & Dvorak 2013). Similarly, HarmoKnee aims to prevent knee injuries while improving movement (Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson, Byberg, 2010). Ayala (2017) showed that the FIFA 11+, HarmoKnee, and dynamic WU acutely induced identical results in developing the range of motion, jumping height in amateur, young females, and male soccer players. In another study (Bizzini 2013) concluded that FIFA 11+ caused better acute performance improvement in sprint, agility, and jumping heights compared to Dynamic WU. Similarly, dynamic WU acutely caused better jumping height and long jump performances in children (Faigenbaum, Bellucci, Bernieri, Bakker, Hoorens 2005; Gelen 2011). In the youth population, training versatility is an important aspect to create and support multidirectional development (Balyi, Way, Higgs 2013; Bompa, Carrera 2015).

Generally, training versatility is considered only for the main phase of the session training. However, the inclusion of the different sort of comprehensive warm-ups periodically may avoid athletes from warm-up uniformity and monotony as long as they similarly optimize and enhance training performance. Although studies previously investigated the acute effects of FIFA 11+, HarmoKnee, and dynamic WU, none of these studies showed their influences in underage categories (U11-12-13-14-15-16). Previously conducted studies in the young population investigated relatively longer-term effects of FIFA 11+ and HarmoKnee (Akbari, Sahebozamani, Daneshjoo, Amiri-Khorasani 2018; Zarei, Abbasi, Daneshjoo, Barghi, Rommers, Faude et al. 2018).

However, we do not know the acute effects of warm-ups in mentioned population. Since the study's purpose is to examine the acute effects of four different warm-up protocols (FIFA 11+, HarmoKnee, dynamic and mixed) on sprint, agility, jumping, and flexibility in U11-12-13-14-15-16 soccer players.

Material and method

Participants

Seventy-two soccer players who compete in the U11-16 (twelve from each) categories participated in the study (Table 1). Participants did not have any musculoskeletal injury in the last 6 months. There was not a familiarization period due to the fact participant's tests regularly are taken. Families were informed and their signed permissions were taken before the study. Ethical committee approval was obtained from Sakarya University of Applied Sciences. In every phase of the study, the Helsinki declaration was followed. As for the ethical issues, it was approved by University Sakarya Social and Human Sciences Ethics Committee on 04.10.2018 (protocol number: 61923333/050.03/).

Table 1

Anthropometric characteristics of the participants

	Average Values					
Age (years)	U11	U12	U13	U14	U15	U16
Body Mass [kg]	35,33 ± 1,7	36,16 ± 2,0	39,91 ± 3,0	57,91 ± 3,5	61,33 ± 2,8	72,16 ± 3,9
Height [cm]	145,58 ± 1,5	142,5 ± 1,3	149,33 ± 2,4	170,66 ± 2,3	172,58 ± 1,9	175,83 ± 3,0

Experimental Approach to the Problem

The study was designed randomly and counterbalanced. Participants' countermovement jump (CMJ), 30 m sprint, Illinois agility, and sit and reach flexibility test were measured after they performed one of the warm-up protocols (FIFA 11+, HarmoKnee, Dynamic warm-up, and Mixed warm-up). The mixed WU protocols were designed as the control protocol, and the other warm-up protocols were designed as the experimental. During this process, any of the participants did not mention any physical problem. Between tests, 2-3 minutes of rest intervals were given. All procedures were performed during one week on non-consecutive days (Monday, Wednesday, Friday, and Sunday). All warm-up and test procedures were conducted at the same time of the day considering diurnal variation. Illinois and 30 m sprint tests were measured in the soccer field while CMJ and flexibility tests were measured on a proper and flat surface by the field. Participants did not perform any physical activity 48 hours before and on the test day. Nutrition consumption was completed 2.5 hours before procedures on the test day. All authors supervised during warm-up and measurement processes.

Warm-up Protocols

FIFA 11+

Volume and intensity adjustments and exercise selections were obtained from the study of Ayala and Bizzini 11+ manual (Ayala, Calderón-López, Delgado-Gosálbez, Parra-Sánchez, Pomares-Noguera, Hernández-Sánchez et al. 2017; Bizzini, Junge & Dvorak 2013). FIFA 11+ contained three sections. The first section included six exercises that consisted of jogging and dynamic stretching (8 minutes). The second section focused on strength-plyometric-balance exercises (10 minutes). The third section consisted of competition and training like running and cutting movements (2 minutes). FIFA 11+ protocol was completed in 20 minutes. All the groups performed level two exercises. Even if we are aware of FIFA 11+ kids are recommended for <14 years old. A study previously used the regular FIFA 11+ warm-up protocol on 10 years old children (Gatterer, Lorenzi, Ruedl, Burtscher 2018).

HarmoKnee Warm-up

Volume and intensity adjustments and exercise selections were obtained from the study of Ayala (Ayala, Calderón-López, Delgado-Gosálbez, Parra-Sánchez, Pomares-Noguera, Hernández-Sánchez et al. 2017). HarmoKnee warm-up protocol contained five sections of warm-up, muscle activation, balance, strength, and core stability, respectively. The first section included five exercises that consisted of jogging, dynamic stretching, and game-based applications (10 minutes). The second section included six exercises that focused on lower extremity muscle activation (2 minutes). The third section included four exercises that consisted of static and dynamic balance skills (2 minutes). The fourth section consisted of three exercises aimed to optimize specific movement patterns with 12-15 repetitions (4 minutes). The fifth and the last section included torso activation and core stability exercises (4 minutes). HarmoKnee protocol was completed in 20-25 minutes.

Dynamic Warm-up

Volume and intensity adjustments and exercise selections were obtained from the study of Taylor and Ayala (Ayala, Calderón-López, Delgado-Gosálbez, Parra-Sánchez, Pomares-Noguera, Hernández-Sánchez et al. 2017; Taylor, Sheppard, Lee, Plummer 2009). The dynamic WU consisted of sixteen exercises that were not specifically split into labeled sections. Activities focused on dynamic stretching, jump, and sprint movements. The dynamic WU protocol was completed in 20-25 minutes.

Mixed Warm-up

The mixed WU consisted of jogging (5 minutes), dynamic (5 minutes) and static stretching (5 minutes) and jogging again (5 minutes). The mixed WU was completed in 20 minutes.

Measurement Procedures

Sit and Reach test

In this test, lower back and lower body posterior muscles' flexibility was assessed. The participant sat and placed his foot to the specific area on the box and then positioned his palms on the gauge showing downwards. While maintaining his knee and ankle extension during the test, tried to move the gauge as far as possible. At the farthest point, he kept his position for two seconds and the test is recorded in centimeter (cm). Two trials were performed, and the best was recorded for data analysis (Jürimäe, Volbekiene1998).

Countermovement Jump

Participant placed his feet straight at the shoulder width and placed his hands on the waist. After squatted to the preferred depth, then immediately jumped. Jumping video recorded with a phone's camera (240 frames/sec). MyJump2 application used to evaluate jump height calculating take-off and landing frames (Balsalobre-Fernández, Glaister, Lockey 2015; Turgut, Çoban, Gelen 2018). Two trials were performed, and the best recorded for data analysis.

30 m Sprint Test

The photocell gates were placed to starting and ending (30 m) points (SE-200 Photocell Gate, İstanbul, Turkey). Participants were asked to cover the distance between the two gates as fast as possible. Two trials were performed, and the best recorded for data analysis (Rommers, Mostaert, Goossens, Vaeyens, Witvrouw, Lenoir et al. 2019).

Illinois Agility Test

Four cones 10 m in length and 5 m in width to each other (square shape) were placed. Photocell gates were positioned to starting and ending points (SE-200 Photocell Gate, İstanbul, Turkey). The other four cones are sequenced and separated 3.3 m from each other and placed in the middle. The sequence was followed during the test; 1-) 10 m run and turn, 2-) go to middle and pass-through cones, 3-) run to next cone up right corner 4-) run to finishing line (Figure 1). Two trials were performed, and the best recorded for data analysis (Reiman, Manske 2009).

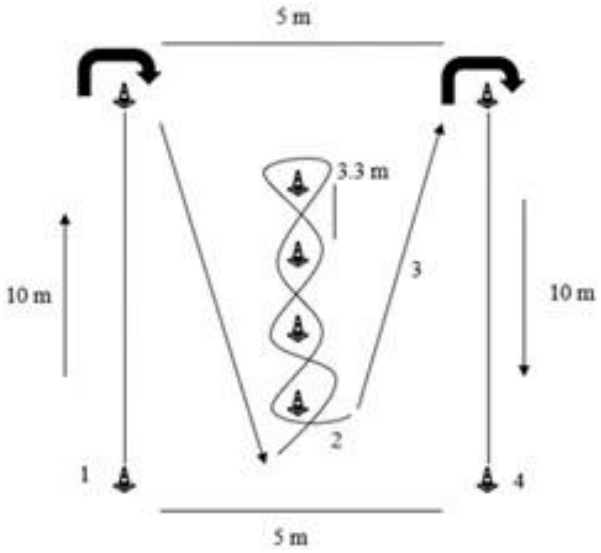


Figure 1
Illınois Agility Test

Statistical Analyses

The means and standard deviation values of all variables were calculated. The Shapiro-Wilk test was used to determine the normality of the data. Repeated measures of the ANOVA test were used to decide intra-group differences (U11-U12-U13-U14-U15-U16) and Bonferroni test was used to determine which protocol caused a significant difference. While the reliability of each test between different warm-ups was determined using the Intra-Class Correlation Coefficient (ICC), the within-test reliability was expressed as the Coefficient of Variation (% CV) (Hopkins 2000). Statistical significance was set at $p < 0.05$. Statistical Package for the Social Sciences (SPSS 16.0, Inc. Chicago, IL) was used to evaluate the results.

Results

The results of the analysis are given below. CV values for all protocols showed moderate confidence (CV% range: 0.64-1.75). ICC values for all protocols were observed as good agreement (ICC: 740-, 895). The acute effects of WU protocols on athletic performance by age are presented in Table 2, 3, 4, 5**.**

Agility Performance

Among the WU protocols, CV values were between 0.80-1.55 and ICC values were in the range of 750-.810. A significant difference was found between the WU protocols in all age groups (i.e; U11 x Fifa11+, Harmoknee, Dynamic WU, Mixed WU) ($p < 0.001$; U11 F = 15730.811; U12 F = 53009.214; U13 F = 226.563; U14 F = 329.669; U15 F = 224.967; U16 F

= 159.843, U11, U12, U13, U14, U15, U16 respectively). A significant difference was found between the age groups of all WU protocols (i.e; Fifa11+ x U11-12-13-14-15-16) ($p < 0.05$; $F = 14.837$; $F = 21.136$; $F = 14.281$; $F = 28.925$, Fifa11+, Harmoknee, Dynamic WU, Mixed WU respectively).

Table 2

The acute effects of WU Protocols on Agility Test by age

Age Groups	FIFA+11 WU	Harmoknee WU	Dynamic WU	Mixed WU	Significance
U11	21,10 ± 1,3 s	21,33 ± 0,5 s	20,99 ± 0,9 s	25,71 ± 0,2 s	p < 0,001
U12	21,06 ± 0,8 s	20,78 ± 0,4 s	21,07 ± 0,4 s	25,81 ± 0,3 s	p < 0,001
U13	20,02 ± 1,0 s	20,02 ± 0,8 s	20,00 ± 0,9 s	25,45 ± 0,3 s	p < 0,001
U14	18,44 ± 1,2 s	18,73 ± 0,7 s	18,72 ± 0,9 s	25,08 ± 0,1 s	p < 0,001
U15	18,84 ± 1,1 s	18,76 ± 1,3 s	18,82 ± 1,0 s	25,14 ± 0,3 s	p < 0,001
U16	18,82 ± 0,5 s	19,03 ± 0,8 s	19,08 ± 1,2 s	24,48 ± 0,3 s	p < 0,001
Significance	p < 0,05	p < 0,05	p < 0,05	p < 0,05	

30 m Sprint Performance

Within the WU protocols, CV values ranged from 0.69-1.32 and ICC values in the range 862-, 889. A significant difference was found between the WU protocols in all age groups (i.e; U11 x Fifa11+, Harmoknee, Dynamic WU, Mixed WU) ($p < 0.001$; $F = 32.925$, $F = 51.018$; $F = 35.529$; $F = 60.958$; $F = 55.477$; $F = 50.881$ U11, U12, U13, U14, U15, U16 respectively). A significant difference was found between the age groups of all WU protocols (i.e; Fifa11+ x U11-12-13-14-15-16) ($p < 0.05$; $F = 22.417$; $F = 18.133$; $F = 28.925$; $F = 35.182$, Fifa11+, Harmoknee, Dynamic WU, Mixed WU respectively).

Table 3

The acute effects of WU Protocols on 30 m Sprint test by age

Age Groups	FIFA+11 WU	Harmoknee WU	Dynamic WU	Mixed WU	Significance
U11	6,31 ± 0,4 s	6,55 ± 0,4 s	6,21 ± 0,2 s	7,16 ± 0,2 s	p < 0,001
U12	6,28 ± 0,3 s	6,20 ± 0,3 s	6,31 ± 0,3 s	7,07 ± 0,3 s	p < 0,001
U13	5,93 ± 0,3 s	5,93 ± 0,2 s	5,95 ± 0,3 s	6,74 ± 0,2 s	p < 0,001
U14	5,53 ± 0,4 s	5,63 ± 0,3 s	5,58 ± 0,1 s	6,38 ± 0,2 s	p < 0,001
U15	5,55 ± 0,3 s	5,66 ± 0,2 s	5,64 ± 0,3 s	6,42 ± 0,2 s	p < 0,001
U16	5,03 ± 0,3 s	5,33 ± 0,4 s	4,98 ± 0,3 s	5,92 ± 0,2 s	p < 0,001
Significance	p < 0,05	p < 0,05	p < 0,05	p < 0,05	

Flexibility Performance

Among the WU protocols, CV values were in the range of 0.87-1.44 and ICC values were in the range of 790-, 867. While there was a significant difference between the WU protocols in all age groups (i.e; U11 x Fifa11+, Harmoknee, Dynamic WU, Mixed WU) ($p < 0.001$; $F = 199.126$, $F = 63.020$; $F = 66.545$; $F = 64.571$; $F = 85.951$, U11, U12, U13, U15, U16 respectively), there was no significant difference among the WU protocols in the U14 age group ($p > 0.05$; $F = 152.814$). There was no significant difference between the age groups of all WU protocols (i.e; Fifa11+ x U11-12-13-14-15-16) ($p > 0.05$; $F = 1.794$; $F = 1.984$; $F = 1.720$; $F = 2.032$ Fifa11+, Harmoknee, Dynamic WU, Mixed WU respectively).

Table 4

The acute effects of WU Protocols on Flexibility Test by age

Age Groups	FIFA+11 WU	Harmoknee WU	Dynamic WU	Mixed WU	Significance
U11	17,41 ± 5.3 cm	18,00 ± 4,1 cm	17,25 ± 4,3 cm	15,75 ± 4,1 cm	p < 0,001
U12	12,66 ± 6.0 cm	14,00 ± 5,1 cm	13,08 ± 5,9 cm	11,41 ± 5,6 cm	p < 0,001
U13	15,66 ± 6.2 cm	16,00 ± 6,6 cm	15,83 ± 7,0 cm	13,41 ± 6,1 cm	p < 0,001
U14	18,66 ± 5.6 cm	18,33 ± 5,6 cm	19,25 ± 4,8 cm	17,5 ± 5,6 cm	p > 0,05
U15	13,91 ± 6.0 cm	13,83 ± 5,9 cm	14,75 ± 6,1 cm	13,16 ± 6,0 cm	p < 0,001
U16	17,83 ± 7.1 cm	19,41 ± 6,7 cm	17,75 ± 6,4 cm	16,91 ± 6,9 cm	p < 0,001
Significance	p < 0,05	p < 0,05	p < 0,05	p < 0,05	

CMJ Performance

Within the WU protocols, CV values ranged from 0.79-1.75 and ICC values in the range of 799-, 895. A significant difference was found between the WU protocols in all age groups (i.e; U11 x Fifa11+, Harmoknee, Dynamic WU, Mixed WU) ($p < 0.001$; $F = 467.992$; $F = 364.201$; $F = 527.159$; $F = 407.248$; $F = 281.272$; $F = 283.168$ U11, U12, U13, U14, U15, U16 respectively). A significant difference was found between the age groups of all WU protocols (i.e; Fifa11+ x U11-12-13-14-15-16) ($p < 0.05$; $F = 10.151$, $F = 9.762$; $F = 10.470$; $F = 10.395$; Fifa11+, Harmoknee, Dynamic WU, Mixed WU respectively).

Table 5

. The acute effects of WU Protocols on CMJ Test by age

Age Groups	FIFA+11 WU	Harmoknee WU	Dynamic WU	Mixed WU	Significance
U11	24,00 ± 3.1 cm	24,58 ± 4,6 cm	24,16 ± 3,9 cm	23,16 ± 3,8 cm	p < 0,001
U12	26,58 ± 4.6 cm	27,66 ± 4,6 cm	27,16 ± 5,5 cm	26,16 ± 4,9 cm	p < 0,001
U13	27,66 ± 4.3 cm	27,33 ± 4,1 cm	27,83 ± 4,3 cm	26,75 ± 4,1 cm	p < 0,001
U14	35,25 ± 5.6 cm	35,0 ± 6,4 cm	35,33 ± 6,4 cm	34,08 ± 6,0 cm	p < 0,001
U15	32,25 ± 6.8 cm	31,83 ± 6,4 cm	32,33 ± 6,6 cm	31,08 ± 6,5 cm	p < 0,001
U16	37,66 ± 8.5 cm	38,75 ± 8,0 cm	38,05 ± 7,3 cm	37,25 ± 7,7 cm	p < 0,001
Significance	p < 0,05	p < 0,05	p < 0,05	p < 0,05	

Discussion

The study aimed to examine the acute effects of the different warm-up protocols on CMJ, flexibility, agility, and sprint performances of soccer players in the U11-16 age groups. In the study, it was found that FIFA 11+, HarmoKnee, dynamic WU protocols were more effective on agility, sprint, CMJ, and Flexibility compared to the mixed WU protocol in the U11-16 age groups as hypothesized. Another important finding was that regardless of the type of warm-up, athletes' jump and sprint performances showed an increment with age.

In the study, it was shown that FIFA 11+, HarmoKnee, and dynamic WU protocols all positively influence agility, sprint, and CMJ performances. Studies in the literature support these results. In a study, Gelen, showed that acute dynamic warm-up increased CMJ height in athletes from different sports (13.3 ± 0.5 years) (Gelen 2011). In another study, Ayala, indicated that any of the FIFA 11+, HarmoKnee, and dynamic warm-up did not cause superior results than another to improve drop jump performance in male and female athletes (19.1 ± 1.3, 20.1 ± 1.8 years) (Ayala, Calderón-López, Delgado-Gosálbez, Parra-Sánchez, Pomares-Noguera, Hernández-Sánchez et al. 2017). However, they concluded that dynamic WU was better to enhance 10 and 20 m sprint performance than FIFA 11+ and HarmoKnee. In another study, it was shown that the FIFA 11+ positively influenced agility performance (Bizzini, Junge & Dvorak 2013). In his study, Gelen, stated that dynamic warm-up caused an increase in muscle stiffness and nervous system activation (Gelen 2011). Bizzini, argued that agility performance enhancement was caused by the rise in muscle and/or core temperature reporting from other studies (Kiani, Hellquist, Ahlqvist, Gedeborg, Michaëlsson, Byberg, 2010; Bizzini, Impellizzeri, Dvorak, Bortolan, Schena, Modena et al. 2013; Thomas, Cheung, Elder, Sleivert 2006). In addition to these explanations, we think that the results are caused by the Post

Activation Potentiation (PAP) effect due to the phosphorylation of myosin regulating light chains which makes actin and myosin more sensitive to ca^{2+}(Hodgson, Docherty, Robbins 2005). Even if there are no additional load interventions in FIFA 11+, HarmoKnee, and dynamic WU protocols of the current study, in support of this claim, other studies showed that small-sided games and relatively low loads corresponding to 5-10 % of body weight elicited the PAP effect (Maloney, Turner, Miller 2014; Zois, Bishop, Ball, Aughey 2011). On the other hand, the mixed WU protocol caused a significantly lower performance compared to other protocols, given that it includes static stretching (SS). It was indicated in a study that during SS alterations in muscle-tendon unit length may impair the force-generation capacity of the muscle, since it may result in a decrease in muscle stiffness (Hough, Ross, Howatson 2009).

Ayala (2017) showed that acutely any of the FIFA 11+, HarmoKnee, and dynamic WU was not more effective than each other to improve the hip, knee, and ankle joint's range of motion. Similarly, in another study, one of the FIFA 11+ and regular warm-up protocols acutely did not cause improvement in the range of motion of the hip, knee, and ankle joints of adolescent athletes (Robles, Pomares Noguera, Ayala Rodríguez, Hernández Sánchez, Martínez Romero, Sainz de Baranda Andújar et al. 2016). In our study, all warm-up protocols except mixed WU revealed similar adaptations in flexibility performance. Although it was previously indicated that the inclusion of static stretching was effective to improve the range of motion (Samson, Button, Chaouachi, Behm 2012). In the support of our findings, another study showed that both static and dynamic stretching included warm-ups positively affected the sit and reach performance (Perrier, Pavol, Hoffman 2011). In our study, dynamic stretching, and specific movement pattern applications at the wide range of motions in FIFA 11+, HarmoKnee and dynamic WU protocols may have induced positive adaptations.

The CMJ and sprint performances of the athletes in U11-12-13-14-15-16 age groups linearly improved, except CMJ height of the athletes in the U15 group did not advance compared to the previous age, In a study, Temfemo, found that boys and girls between 11-16 years old linearly improved their jumping performance by age (Temfemo, Hugues, Chardon, Mandengue, Ahmaidi 2009). They explained that this development was induced muscular development as well as reporting from Bobbert and Casius, changes in the length of contractile elements in the muscle-tendon structure (Bobbert, Casius 2005). Especially, the development of the tendon structure length increases its energy storage capacity (Challis 2000). The energy storage capacity of the tendon is important in movements that use the stretch-shortening cycle, such as CMJ and sprint. It was reported that children are in the adolescent period between 12 and 16 years old, the improvement is naturally obtained through maturation-related adaptations

such as increased androgen concentration, muscle fibril differentiation, changes in resting adhesonine triphosphate, and creatine phosphate levels (Lloyd, Oliver 2012). The anatomical and physiological developments with maturation explain the improvement in sprint and jump performances that occur independently from the warm-up.

Conclusions

FIFA 11+, HarmoKnee, and dynamic WU showed identical effects in U11-16. Firstly, FIFA 11+ and HarmoKnee can be preferable compared to dynamic WU since they both promise injury prevention and do not have any performance impairment. Secondly, all these three comprehensive and dynamic warm-up protocols can be used to avoid young athletes from warm-up monotony. Additionally, it should be kept in mind that growth and maturation-related factors can have a significant effect on warm-up and test performance.

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