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ORIGINAL ARTICLE

Effects of different stretching methods on speed and agility performance in young tennis players

Effets de différentes méthodes d'étirement sur la vitesse et l'agilité des jeunes joueurs de tennis

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Summary
Purpose. — The purpose of this study was to investigate the acute effect of different stretching methods on speed and agility performance in young tennis players according to conditioning level.
Methods. — Twenty-six young tennis players participated in this study voluntarily. Stretching methods were divided into five groups: static, dynamic, static + dynamic, dynamic + static, and control (no-stretching). The protocols included 8-min warm-up, a 3-min rest, 30-s stretching program (except for the no-stretching group), a 2-min rest, followed by the T-drill agility and 20-m sprint (with 10-m split times) test. Stretching protocols consisted of 6 different stretching exercises for 6 lower muscle groups.
Results. — Dynamic and static + dynamic stretching methods induced significant differences in the 10-m acceleration, 20-m sprint and agility test time compared with static and static + dynamic stretching protocols ($P < 0.05$). Dynamic and no-stretching methods also showed significant difference between good and moderate performers compared with static, static + dynamic and dynamic + static stretching protocols ($P < 0.05$).
Conclusion. — We concluded that the acute effect of static stretching had a negative effect on agility and sprint performances. This study suggest that dynamic and static + dynamic stretching might be use for the performing better performance in acceleration, speed and agility skills during the warm-up session in young tennis players.

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Stretching ;
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Résumé
Objectif. — Le but de cette étude était d'étudier l'effet aigu de différentes méthodes d'étirement sur la vitesse et performance de l'agilité des jeunes joueurs de tennis selon le niveau de conditionnement.
Méthodes. — Vingt-six jeunes joueurs de tennis ont participé volontairement à cette étude. Les méthodes d'étirage ont été divisées en cinq groupes : statique, dynamique, statique + dynamique, dynamique + statique et contrôle (sans étirement). Les protocoles comprenaient un échauffement de 8 minutes, un repos de 3 minutes, un programme d'étirement de 30 s (sauf le groupe sans étirement) un repos de 2 minutes, suivie de l'agilité T-drill et du sprint de 20 m (les temps divisés avec 10 m) tester. Les protocoles d'étirement se composaient de 6 exercices d'étirement différents pour 6 groupes musculaires inférieurs.
Résultats. — Les méthodes d'étirement dynamique et statique + dynamique ont induit des différences significatives dans l'accélération de 10-m, le sprint de 20-m et le temps d'essai d'agilité par rapport aux protocoles d'étirement statiques et statiques + dynamiques ($p < 0{,}05$). Les méthodes dynamiques et sans étirement ont également montré une différence significative entre les performances bonnes et modérées par rapport aux protocoles d'étirement statiques, statiques + dynamiques et dynamiques + statiques ($p < 0{,}05$).
Conclusion. — Nous avons conclu que l'effet aigu de l'étirement statique avait un effet négatif sur l'agilité et les performances de sprint. Cette étude suggère que dynamique et statique + dynamique pourraient être utilisés pour une meilleure performance en termes d'accélération, de vitesse et d'agilité lors de la séance d'échauffement dans de jeunes joueurs de tennis.

1. Introduction

Tennis is an anaerobic sport with aerobic breaks between the rallies, making players perform short bursts of high-intensity exercise interspersed with periods of rest or low-intensity activities over a prolonged period (2—4 hours) [1—3]. Consequently, tennis players need to possess tennis-specific physiological characteristics such as muscle strength and flexibility. These performance determinants are improving tennis match performance [4]. Therefore, sport scientists and players have been using different stretching methods such as static stretching, dynamic stretching and combined (static + dynamic or dynamic + static) stretching, prior to training [5] and match performances [6] in tennis players.

In many recent studies, static stretches that are commonly used in order to improve muscular performance in elite and amateur level athletes [6,7] in different team and individual sports [5,8] with different durations [9,10] before exercise and athletic performance. However, this stretching method causes a decrease in isometric [11,12] and isokinetic power responses [13,14], and also adversely affects performance responses such as sprint time [8,15], jump height [15,16], agility [17,18], power [13,19] and reaction time [20]. In one of the studies with striking results, Gelen et al. [18], have observed a considerable decrease of 8.5% in sprint performances, and 4.1% in slalom dribbling performances of the participants doing static stretch compared to the control group. In addition to these important results, Amiri-Khorasani et al. [17], have shown a decrease of 5.6% in the agility test performance. Contrast to these study results, it has been determined that dynamic stretches have a positive effect on the speed [6,8,21] and agility performances [17,18,22] required for each sports. These results support that the dynamic stretches done instead of the static stretching exercises in warm-up section increase the test performances.

Moreover, in recent studies comparing the effect of different stretching exercises on performance, when the effect of the combined stretches on the speed and agility performances is examined [8,17,23], conflicting and unclear results are seen due to the fact that the participants' performed sports, ages, and stretching exercises they chose are different. Although there are a few studies evaluating the acute effects of static and dynamic stretching on vertical jump [6,24], sprint [6], agility [25] and tennis serve performances [5,6,26], to our knowledge, no studies have researched on the acute effects of different stretching methods on agility and sprint performance in tennis. Based on previous some studies suggesting a decrease in agility and sprint performances after static stretching [8,17], it is hypothesized that there would be an acute decrease in these performance responses followed by the static stretching exercises, while performing dynamic and combined stretching would be increase the agility and sprint performance. Therefore, the purpose of this study was to compare the acute effect of different stretching methods on acceleration, speed and agility performances to determine which of these stretching methods is more effective on test performances in young tennis players according to conditioning level.

2. Material and methods

2.1. Participants

Twenty-six nationally ranked male young tennis players volunteered to participate in this study. Players were accustomed to anaerobic (i.e., sprint and agility) and flexibility (i.e., static and dynamic stretching) training in their training sessions. At the time of the study, the players were not involved in any training or matches. Inclusion criteria included:

- absence of musculoskeletal injuries for at least 6 months before the study;
- active participation to trainings (≥ 4 to 5 days per week, each session lasting ∼80 minutes);
- training experiences at least 2 years.

In order to determine the effect of performance level at different stretching methods on agility and sprinting, players were classified as good performers (GP, $n = 13$) or moderate performers (MP, $n = 13$) according to 20-m sprint test reference values for U14 tennis players in the study of Fernandez-Fernandez [27]. Prior to testing, all players and parents were notified of the research procedures, requirements, benefits, and risks before giving written informed consent. This study was approved by the research ethics committee of local university, and was conducted in a manner consistent with the institutional ethical requirements for human experimentation in accordance with the Declaration of Helsinki. There were no subjects injured or abandoned during the study.

2.2. Procedures

All players participated a total of 11 sessions (including a session for familiarization) and data were collected during the 2016-2017 pre-competitive season without any matches. This short procedure was chosen to minimize any performance changes that could occur over a longer time period. All players participated in the five stretching methods:

- static stretching (SS);
- dynamic stretching (DS);
- static + dynamic (CSD);
- dynamic + static (CDS);
- control (no stretching).

Speed and agility testing order was randomly selected for players with 48-hours rest intervals. The protocols consisted of 8-min general warm-up, a 3-min rest, 30-s stretching program for each muscle group (except for the no-stretching group), a 2-min rest and then the T-drill agility test and 20-m straight sprint (with 10-m split times) test. Stretching exercises were designed to stretch the main lower extremity muscle groups. Both static and dynamic stretching protocols stretched the same groups according to the previously repeated procedures of Amiri-Khorasani's study [8]. The experimental procedure is summarized in Fig. 1. All measurements were performed on an indoor hard court, eliminating the wind resistance or inclement weather, at the same time of the day.

2.3. Agility and sprint tests

In order to assess the agility performance, T-drill test was used in the present study. T-drill test reliability and validity were established in a previous study [28]. For sprint test, players performed maximal 20-m sprints (with 10-m split times) interspersed with 3 minutes of passive recovery. These tests were performed from a standing start position 0.5 m behind the first timing gates and were assessed using a portable electronic timing gates (Newtest, Finland). Each

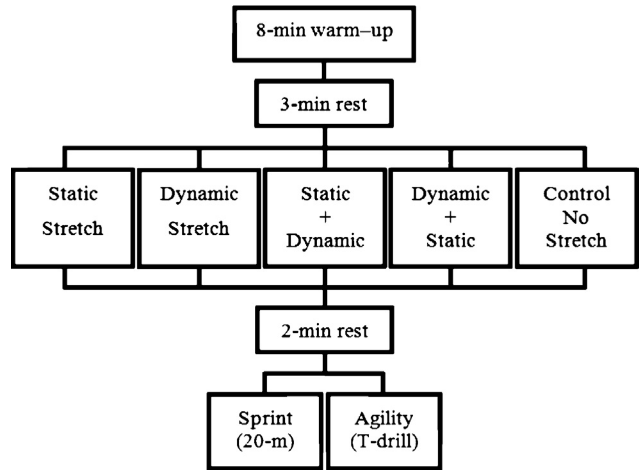

Figure 1 Experimental design.

player had two trials for all performances tests separated by 3 minutes of passive resting because lower times reflect better performance [29] and the best trial was used for calculations. The players were verbally encouraged by their team coach to perform maximal efforts during the all tests. The reliability of the performance tests (ICC) demonstrated high reliability (range: 0.90—0.94) according to the evaluation established by a study [30].

2.4. Warm-up and stretching protocols

Subjects performed a 8-minutes a standardized general warm-up consisting of low to moderate intensity jogging, skipping, side and back stepping in order to prepare performance. All players were instructed to stretch for a duration of 30-seconds at pain of discomfort for each the main lower extremity muscle groups: hamstrings, quadriceps, gastrocnemius, hip flexors, hip extensors and adductors during both static and dynamic stretching. There was no rest between different stretching exercises. All stretching exercises were performed by both legs with the assistance of the instructor. The dynamic stretching were performed slowly and continuously without any bouncing during the exercises. In order to equalize the total duration of stretching, the number of sets of combined stretching exercise (CSD or CDS) was reduced from 2 sets to 1 set for each muscle group of both legs. In the control group, the players rested after the 8-min warm-up session.

2.5. Statistical analysis

The data are reported as means and standard deviations. Before using parametric tests, the assumption of normality was verified using the Shapiro-Wilk test. The effect of different stretching methods on agility and sprint performance was determined using one-way repeated-measures analysis of variance (Anova). A 2 (group) × 5 (conditions) repeated measures Anova was used to analyze the results of the good and moderate performers' players over 5 different stretching methods. When justified, paired t-tests were performed to confirm significant changes within each condition. Confidence interval (%95 CI) was calculated for the difference between mean values for each of the variables and the effect size ($\eta 2$) was calculated for each dependent variable. Reliability of each test was assessed by intraclass correlation

Table 1 Physical and performance characteristics of participants.

	Good performers	Moderate performers	All players
Age (years)	13.5 ± 0.2	13.3 ± 0.3	13.4 ± 0.3
Height (cm)	151 ± 5	153 ± 3	152 ± 4
Weight (kg)	45.5 ± 4.2	46.9 ± 4.8	46.2 ± 4.5
Training experience (years)	2.2 ± 0.2	2.3 ± 0.2	2.3 ± 0.2
10-m sprint (s)	1.93 ± 0.05	1.97 ± 0.04	1.95 ± 0.05
20-m sprint (s)	3.39 ± 0.06	3.47 ± 0.05	3.43 ± 0.06
T-drill test (s)	11.21 ± 0.32	11.67 ± 0.38	11.44 ± 0.35

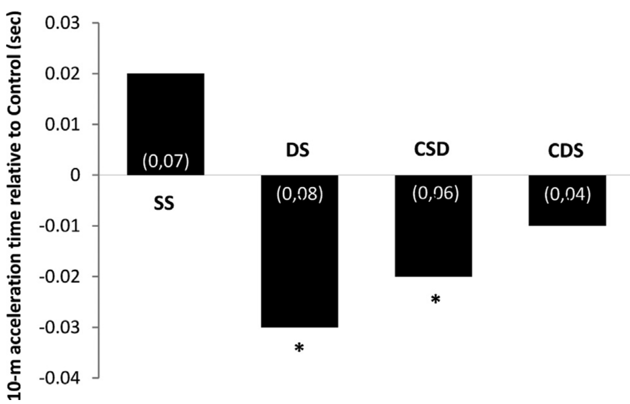

Figure 2 10-m sprint time (acceleration) relative to control (no stretch). SS: static stretching; DS: dynamic stretching; CSD: combined static + dynamic stretching; CDS: combined dynamic + static stretching. * Significant differences are shown between static and dynamic, and static and combined static and dynamic stretching methods ($P < 0.05$). (Values in parentheses indicate standard deviations).

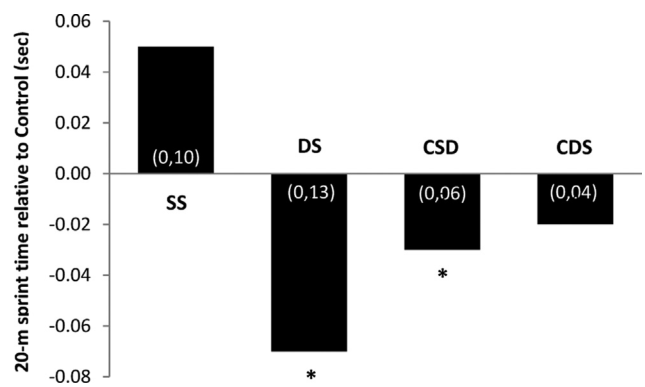

Figure 3 20-m sprint time relative to control (no stretch). SS: static stretching; DS: dynamic stretching; CSD: combined static + dynamic stretching; CDS: combined dynamic + static stretching. * Significant differences are shown between static and dynamic, and static and combined static and dynamic stretching methods ($P < 0.05$). (Values in parentheses indicate standard deviations).

coefficient (ICC). Statistical analyses were performed using the SPSS version 20.0 and statistical significance was set at $P < 0.05$.

3. Results

Table 1 shows the physical characteristics of participants.

The results showed that there were significant differences in 10-m acceleration, 20-m sprint and T-drill agility time among DS, SS and CDS ($P = 0.001$; $\eta^2 = 0.65$ for 10-m, $\eta^2 = 0.69$ for 20-m and $\eta^2 = 0.77$ for agility). In addition, significant differences found in 10-m acceleration, 20-m sprint and T-drill agility time among CSD, SS and CDS ($P = 0.001$; $\eta^2 = 0.57$ for 10-m, $\eta^2 = 0.60$ for 20-m and $\eta^2 = 0.67$ for agility), but no significant differences found between DS and CSD, as illustrated in Figs. 2—4.

The good performance group demonstrated a better performance in 10-m acceleration ($\eta 2 = 0.88$), 20-m sprint ($\eta 2 = 1.45$) and T-drill agility time ($\eta 2 = 0.72$) in DS group compared to moderate performance group ($P < 0.05$). In addition, better performance was found in 10-m acceleration ($\eta 2 = 0.91$), 20-m sprint ($\eta 2 = 1.49$) and T-drill agility time ($\eta 2 = 0.78$) in good performance group in control compared to moderate performance group ($P < 0.05$), as demonstrated in Figs. 5—7.

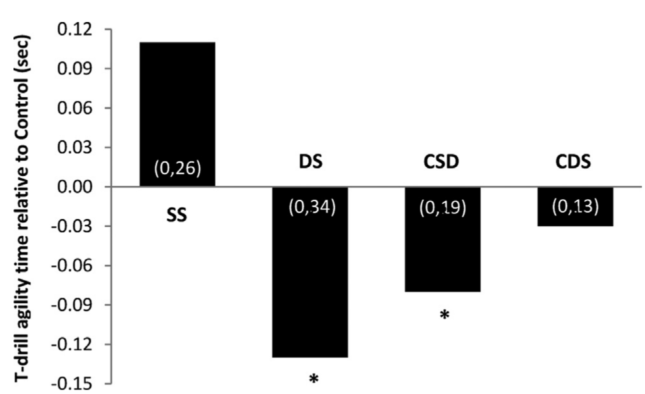

Figure 4 T-drill agility time relative to control (no stretch). SS: static stretching; DS: dynamic stretching; CSD: combined static + dynamic stretching; CDS: combined dynamic + static stretching. * Significant differences are shown between static and dynamic, and static and combined static and dynamic stretching methods ($P < 0.05$). (Values in parentheses indicate standard deviations).

4. Discussion

The aim of this study was to compare the acute effect of different stretching methods on acceleration, speed and agility performances to determine which of these stretching methods is more effective on test performance time in young tennis players according to conditioning level. To our knowledge, this is the first study to examine the acute effects of different stretching methods on acceleration, speed and agility performances of young tennis players. The main findings of this study is that the acute effect of static stretching induce a negative effect on agility and sprint performances. In other words, dynamic and combined stretching (static + dynamic) induced significant increase in performance of acceleration, speed and agility. Another important finding of the present study is that the effects of different types of stretching exercises on acceleration, speed and agility performances might be depend on the condition levels.

Numerous studies have investigated the acute effect of dynamic or combined stretching which is the suggested stretching methods in order to increase athletic performance responses [8,21,31,32]. Many studies have demonstrated that dynamic or combined stretching have positive effects on power responses [14,19] and also positively affects performance responses such as sprint time [21,33], jump height [6,24] and agility [17,22]. The present study is in agreement with the majority of recent studies reported that dynamic or combined stretching improve performance in sprint time [8,21,33,34] and agility [17,22,25,31]. For example, Little and Williams [31] have stated that acute dynamic stretching improves the test performances of acceleration, speed and agility in professional soccer players. In addition, Amiri-Khorasani et al. [8], have also shown that players performed better performance in terms of acceleration and speed after dynamic and combined stretching exercises compared with the static and no-stretching methods in young soccer players. However, only a few studies in the literature have shown no effects of dynamic or combined stretching on the speed and agility performances [23,35]. In one of these studies, Bishop and Middleton [35] have not found any difference in 20-m speed and agility test performances of the participants who did dynamic and combined stretch in sports students at university. In another similar study, Chaouachi et al. [23], have also showed that different stretching applications have not any positive effect on the anaerobic test performances such as speed, agility, and jumping in student-athletes in sports sciences at university. Contradictory findings in results of studies might be explained by features of different participant groups such as different

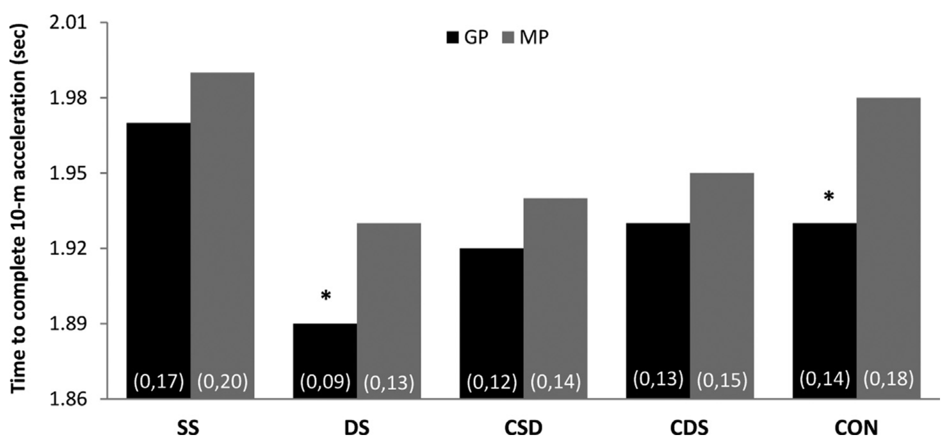

Figure 5 10-m sprint time (acceleration) between good and moderate players. SS: static stretching; DS: dynamic stretching; CSD: combined static + dynamic stretching; CDS: combined dynamic + static stretching; CON: no-stretching. * Significant differences in dynamic and control groups between good and moderate players ($P < 0.05$). (Values in parentheses indicate standard deviations).

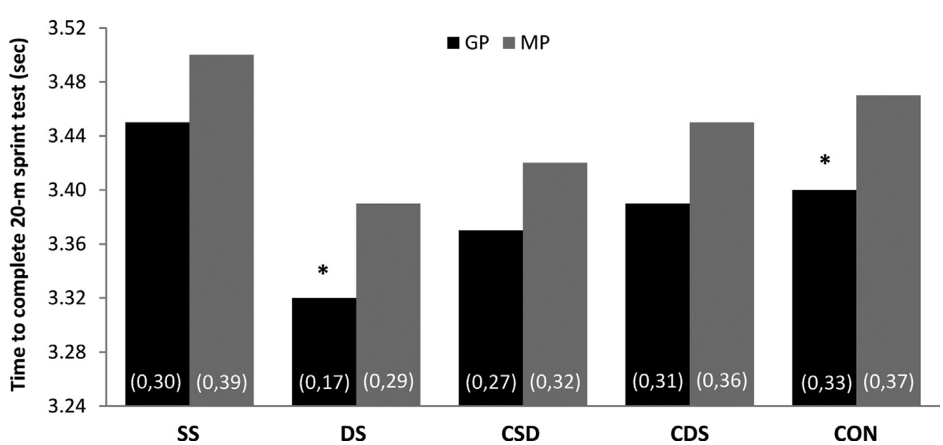

Figure 6 20-m sprint time between good and moderate players. SS: static stretching; DS: dynamic stretching; CSD: combined static + dynamic stretching; CDS: combined dynamic + static stretching; CON: no-stretching. * Significant differences in dynamic and control groups between good and moderate players ($P < 0.05$). (Values in parentheses indicate standard deviations).

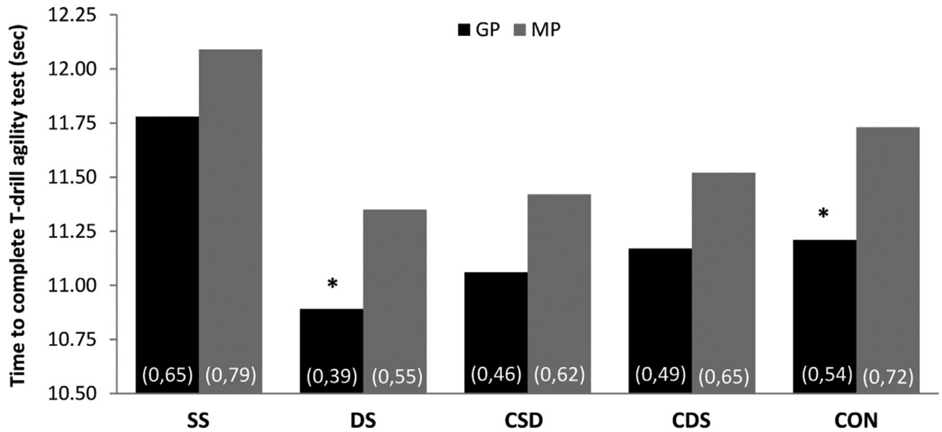

Figure 7 T-drill agility test time between good and moderate players. SS: static stretching; DS: dynamic stretching; CSD: combined static + dynamic stretching; CDS: combined dynamic + static stretching; CON: no-stretching. * Significant differences in dynamic and control groups between good and moderate players ($P < 0.05$). (Values in parentheses indicate standard deviations).

sports branches and training status [9,17], different time and sets of the stretching [9,10]. In addition to these affecting factors, type of the stretching application (one leg at different times, or two legs at the same time) may cause emergence of different results. Furthermore, the improved speed and agility performance responses after the dynamic and combined stretching might be explained with increased muscle blood flow (related to core or peripheral temperature) which positively affects the post-activation potentiation [8,21,31]. In addition, dynamic stretching may induce a positive effect on the stretch-shortening cycle with a greater action potential that may result in enhancing muscular performance [6,23]. In other words, static stretching showed a worst average score for speed and agility test performances according to the present study findings. Many studies have previously examined the effects of static stretching on acceleration, sprint and agility performances [8,17,22,25]. In one of them, Amiri-Khorasani et al. [8], found that static stretching has adverse effect on both 10-m and 20-m sprint performances in young soccer players. Amiri-Khorasani et al. [17], also investigated the effects of three stretching protocols: static, dynamic and combined methods in soccer players. They reported that static stretching affected agility performance negatively except for the dynamic stretching protocol. Potential reasons for adverse effect on performances such as speed and agility after static stretching might be mechanical factors involving the muscle viscoelastic properties that may affect the musculotendinous unit and neural factors such as decreased muscle activation or altered reflex sensitivity [13,36,37].

Various stretching techniques, including static, dynamic and combined stretching techniques are performed in order to enhance the important performance indicators, such as speed and agility, which require acceleration in warm-up section prior to performance [8—10]. To our knowledge, a few studies investigated the acute effects on the speed and agility test performances at different training age [17] and condition levels [9] after different stretching methods. Amiri-Khorasani et al. [17], showed that increased training age positively affects the agility performance both in the dynamic stretching group and the control group in soccer players. Many studies with young players demonstrated that the fitness level of the participants plays an important role in identifying talented players and selection for the game [38,39]. Moreover, it is known that the professional athletes are better in the sprint and agility performances compared to the amateur athletes. In another study, Avloniti et al. [9], found that different condition levels such as high and moderate have showed differences in acceleration and speed performance after static stretching for 15—20 seconds in trained athletes. Furthermore, static stretching for 10—15 seconds in agility performance have caused difference between high and moderate groups. In accordance with the results from the literature, our results showed that a significant decrease in speed and agility test time between the dynamic stretching and control group at different condition levels as good and moderate. In our study, the players were classified as good or moderate performers in order to determine the effect of performance level at different stretching methods on agility and sprinting according to their performance in speed test and their training ages are very close to each group. However, viscoelasticity of the muscle tendon structures [40] and leg stiffness which is related to maximum sprint velocity [41] could be differentiate these performance responses.

Although, this is the first study to examine the acute effects of different stretching methods on acceleration, speed and agility performances of young tennis players, some limitations should carefully be noted before final conclusions are drawn. Firstly, the study did not analyze the chronic effect of different stretching methods on match related performances such as speed and agility. Another limitation is the small sample size given the participants each level of groups were young tennis players. However, a major strength of this study is that speed and agility testing order was randomly selected in order to minimize the possible effect of the stretching methods on performance results. Another major strength of our study is that the short-term procedure was chosen to minimize any performance changes that could occur over a longer time period.

5. Conclusion

In summary, this study examined the acute effects of different stretching methods on speed and agility performance in young tennis players according to conditioning level. This study showed that dynamic and combined (static + dinamic) stretching may improve speed and agility performance in young tennis players. This study also showed that conditioning level affect the speed and agility performance outcome positively. According to our results, coaches and sport scientists should take into account selecting stretching type after the warm-up session. Furthermore, dynamic and combined (static + dinamic) stretching should be performed in order to increase the speed and agility performances of their players. Based on these results, as shown in many studies in the literature, dynamic stretching exercises should select in order to positive effect on the test performances instead of static stretching especially in the warm-up section.

Disclosure of interest

The authors declare that they have no competing interest.

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