Maturation Stage Does Not Affect Change of Direction Asymmetries in Young Soccer Players

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Abstract

Asimakidis, ND, Dalamitros, AA, Ribeiro, J, Lola, AC, and Manou, V. Maturation stage does not affect change of direction asymmetries in young soccer players. *J Strength Cond Res* XX(X): 000–000, 2021—This study examined whether the stage of biological maturation can affect interlimb asymmetries during a change of direction (COD) test. Seventy-six young soccer players were divided into 2 different groups according to their peak height velocity stage (PHV): pre-PHV ($n = 45$, age $= 11.8 \pm 1.2$ years, height $= 149.8 \pm 9.3$ cm, body mass $= 43.9 \pm 11.2$ kg) and post-PHV ($n = 31$, age $= 14.4 \pm 0.9$ years, height $= 170.0 \pm 4.9$ cm, body mass $= 61.5 \pm 8.9$ kg). Subjects performed a 505 test to measure the completion time in both directions and a 20-m maximum sprint test. Change of direction deficit (CODD) was used as a measure for isolating COD ability. An independent sample *t*-test detected no significant differences between the asymmetry index values for the 505 test completion time when the pre-PHV group and the post-PHV group were compared ($-3.49 \pm 2.49\%$ vs. $-3.45 \pm 2.47\%$, effect size [ES] $= 0.02$, $p = 0.923$). Similarly, the CODD asymmetry index indicated no differences between the 2 groups ($-8.21 \pm 5.95\%$ vs. $-7.37 \pm 5.12\%$, ES $= 0.15$, $p = 0.457$). A paired sample *t*-test revealed that the values of the CODD asymmetry index were larger than those of the 505 asymmetry index ($-7.88 \pm 5.61\%$ vs. $-3.49 \pm 2.46\%$, ES $= 1.09$, $p < 0.001$). According to these results, maturational status has no influence on the interlimb asymmetries of COD ability. Furthermore, subjects showed greater asymmetry values in CODD compared with the 505 test completion time, reinforcing that the evaluation of COD asymmetries should be based on CODD. As interlimb asymmetries are not altered during the maturation process, practitioners should address abnormal COD asymmetries early on during athletes' development processes.

Key Words: interlimb differences, peak height velocity, agility, football

Introduction

Change of direction (COD) ability, defined as "the ability to change initial direction to a predetermined location and space on a field or a court" (12,35), is considered essential in multidirectional team sports. Soccer is an intermittent-type activity that includes a variety of turns in different directions (4). A high level of COD ability is vital for successful performance on the field because it is related to crucial game situations (9,27). Change of direction ability is strongly influenced by several physical attributes (e.g., acceleration, linear speed, eccentric/concentric strength, and power), and the different levels of capability on multidirectional speed can be a distinguishing factor between soccer players of different chronological ages and competitive levels (4,27). As such, it is expected that younger and less experienced players present less developed athletic skills and a lack of movement strategies, which, in turn, may affect their COD ability. In fact, Loturco et al. (26) and Fiorilli et al. (15) have recently analyzed COD ability according to soccer players' chronological age, reporting that the younger players presented the lowest levels of COD ability. In this sense, the continuous effort of practitioners to design and implement the most appropriate training interventions to optimize players' COD levels seems reasonable (23).

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A crucial stage during long-term athletic development is the developmental period when numerous neurological and hormonal alterations occur (21). Biological maturation refers to the process of progressing toward a mature state and varies between individuals in its magnitude (extent of change), timing (onset of change), and tempo (rate of change) (22). Previously, a large variation in biological maturity in soccer players of the same chronological age was reported (30). It has been shown that both the physical and psychosocial development of children may be influenced by an individual's level of maturity (20). Specifically, early-maturing boys show higher positive self-perception and possess higher levels of self-esteem compared with their peers (5). A commonly used method for the estimation of biological maturation status is peak height velocity (PHV), which refers to the maximum rate of growth in stature (21). A meaningful finding is that during the maturation process, young athletes tend to experience impairments in motor control, which, in turn, seem to increase the likelihood of establishing interlimb asymmetries (28,40). Indeed, according to previous studies that examined the effect of maturation on interlimb asymmetries in a variety of sports, interlimb asymmetries were heightened during and after the attainment of PHV (1,28,40). However, the lower-limb asymmetry indexes derived from ground reaction forces during a deep squat exercise (1), completion times during the 505 test (28), and single-leg countermovement jumping are not influenced by maturation. It should be noted that achieving an optimal level of symmetry between the right and left sides of athletes' bodies is of paramount importance when attempting to maximize athletic performance, considering that a greater extent of interlimb asymmetries can result in impaired performance and a higher risk of injury (2,3,14,37,39).

Many different field tests have been applied to assess COD ability (e.g., Pro-Agility test, L-run test, T-test, Illinois Agility test, and 505 test) (36). Owing to its simplicity and the minimal equipment required, the 505 test is becoming increasingly popular for the evaluation of COD ability in many different sports (13). Nevertheless, the 505 test completion time is likely to overestimate or underestimate COD ability because the time that is actually spent on executing the turning movement corresponds only to approximately 31% of the total test's duration (34). As a result, acceleration time can influence the final outcome to a great extent (12,25,34,36). This fact can be perceived as a methodological issue when aiming to evaluate the performance level of this ability. Consequently, the term "change of direction deficit" (CODD) has been recently introduced to effectively distinguish COD ability from acceleration and linear speed (6,8,24). Change of direction deficit is traditionally assessed as the difference between the 10-m split time during a linear sprint (20 or 30 m) and the 10-m split with a 180° cut that is measured in the 505 test (36). In this sense, the CODD reports the effect of a directional change (or the additional time that one directional change requires) when compared with a pure linear sprint over an equivalent distance.

During soccer-related training and match play, the appearance of abnormal interlimb asymmetries is usually promoted because of the highly unilateral requirements (16). According to previous research, an optimal range value of asymmetry index fluctuates between values that are lower than 10% (35,40). The mechanism underlying the existence of interlimb asymmetries is laterality. Laterality is defined as the preferential use of one limb during voluntary motor actions and is related to a functional imbalance between the 2 hemispheres of the human brain (42). Following the hypothesis that CODD can accurately reveal the actual performance level of COD ability, 2 previous studies attempted to examine the COD asymmetries through CODD testing (8,12). Both studies showed that CODD asymmetries are significantly greater than the asymmetries measured through the 505 test completion time. Regarding soccer-related studies, COD asymmetry according to different age categories has presented some controversial results. Recently, Trecroci et al. (43) found no differences in CODD according to chronological age (U15 to U18), whereas Loturco et al. (26) showed that CODD increased alongside age (U15 to senior). However, in both cases, age was the only parameter considered while no analysis related to maturation status was performed.

No study to date has attempted to quantify the effects of maturation on CODD asymmetries. This information could be of great significance for practitioners because it can promote the proper identification of interlimb asymmetries related to COD ability, which, in turn, can lead to the design of appropriate training programs in young soccer players according to their maturation status. Therefore, the primary purpose of this study was to examine whether the maturational process (evaluated using the PHV index) can affect COD asymmetries. A secondary purpose was to compare the percentages of COD asymmetry indexes in young soccer players during a 505 test. It was hypothesized that significant differences in the asymmetry indexes would be revealed between pre-PHV and post-PHV groups and that significant differences between CODD and the 505 test completion time asymmetry index would be noted.

Methods

Experimental Approach to the Problem

This study examined the effect of biological maturation status on COD asymmetries in young soccer players using a cross-sectional design. The subjects were divided into 2 groups (pre-PHV and post-PHV) according to their maturation status. The COD asymmetries were assessed by means of the 505 test. Two distinct ways of computing the COD asymmetries (505 asymmetry index and CODD asymmetry index) were used to analyze the effect of maturation.

Subjects

Seventy-six young soccer players, aged between 10 and 16 years, were classified into 2 different groups according to their PHV stage: pre-PHV ($n = 45$; age = 11.8 ± 1.2 years; height = 149.8 ± 9.3 cm; body mass = 43.9 ± 11.2 kg) and post-PHV ($n = 31$; age = 14.4 ± 0.9 years; height = 170.0 ± 4.9 cm; body mass = 61.5 ± 8.9 kg; ± *SD*). The testing procedures were performed during the competitive period. At that time, subjects had a training frequency of 3–4 training sessions per week—including a strength and conditioning training session—plus a competitive game in the regional youth championship. Subjects were injury-free during the study period, and they were instructed to avoid strenuous exercise the day before testing. Testing procedures were performed while subjects were in an optimal nutritional and hydration state. All subjects and their parents were informed about the aim of the study, the procedures, as well as the benefits and potential risks of this study. Because the entire group of the subjects in this study was younger than18 years, a written parental informed consent form was signed by all athletes and their parents. The investigation was approved by the institutional review board of Aristotle University of Thessaloniki.

Procedures

On their arrival, subjects' anthropometric measures—namely standing height, sitting height, and body mass—were measured. These data were further used to determine players' maturational status and to estimate their biological maturation stage.

Afterward, a standardized warm-up was performed that consisted of 10 minutes of jogging, low-intensity plyometric drills, dynamic stretching, and linear and multidirectional sprints. Testing procedures were applied at the club's facilities on an artificial turf surface in the following order: 20-m sprint test and 505 COD speed test. A five-minute rest period was allowed between the warm-up and the 20-m sprint test as well as between the 20-m sprint test and the 505 test. Bilateral asymmetries were defined in both the 505 and the CODD test through the following norm: (dominant leg − nondominant leg)/dominant leg × 100 (12,23). The asymmetry threshold was determined by the following norm: mean imbalance − (0.2 *SD* of the mean) (12,23). Subjects with values that exceeded this threshold were characterized as asymmetrical.

Biological Maturation. The stage of biological maturation was calculated in a noninvasive manner using an estimation equation that included measures of chronological age, body mass, and standing and sitting height (32). Maturity offset was defined as years from PHV. The predicting equation was

maturity offset = −9.236 + [0.0002708 × leg length and sitting height interaction] − [0.001663 × age and leg length

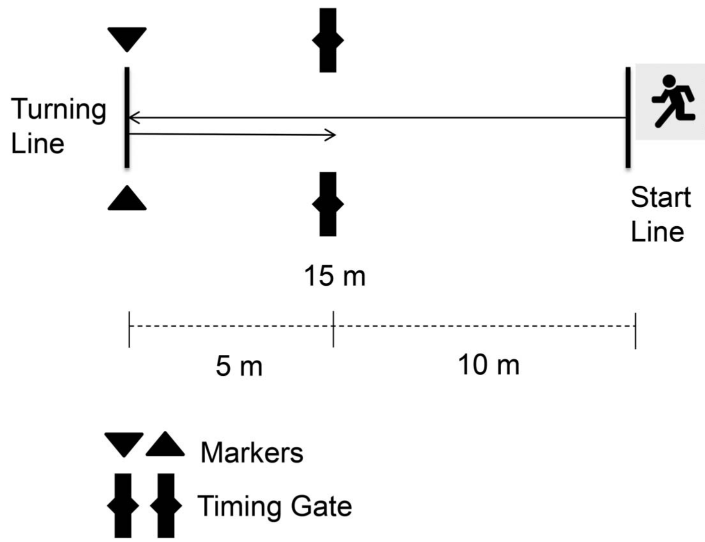

Figure 1. Schematic representation of the 505 testing procedure.

interaction] + [0.007216 × age and sitting height interaction] + [0.02292 × body mass by height ratio].

Subjects who displayed a PHV value below 0 were included in the pre-PHV group, whereas subjects with a greater or equal value than 0 were included in the post-PHV group.

20-m Sprint Test. The 20-m sprint time was recorded using a timing lights system (WITTY System, Microgate). Gates were positioned at 0, 5, 10, and 20 m at a width of 2.5 m and approximately hip height (44). The best split time from 10 to 20 m (serving as a measure of maximum pure velocity) was further used to estimate CODD. Subjects were instructed to assume a standing start position with their front foot 0.3 m behind the first gate to impede the premature triggering of the first gate. They freely chose the foot placement during the starting stance. Subjects were instructed to run maximally through all timing gates once they initiated their sprint. Time was recorded to the nearest 0.001 seconds. Each subject completed 3 trials, with 3 minutes of recovery given between trials. The fastest trial was used for further analysis.

505 Change of Direction Speed Test. The 505 test was the selected testing procedure to evaluate subjects' COD abilities because it has been used previously in a soccer context (29). During this procedure, the performance of each limb can be assessed separately (36). The same starting position after the 20-m sprint test was used here. Subjects were instructed to sprint through the gate to a line marked 15 m from the start line, perform a 180° turn by placing either foot on the ground (depending on the trial), and finally sprint back 5 m through the gate. A research associate was placed at the turning line to assure that the trial was valid. If the subjects performed the turn before hitting the turning line or changed direction with the incorrect foot, the trial would be disqualified, and the subject would complete another trial after the rest period. The time for each distance was recorded to the nearest 0.001 seconds. Each subject completed 2 trials for each limb, with 3 minutes of recovery given between trials. The fastest trial for each limb was used for further analysis. The plant foot that produced the fastest time during the 505 test was defined as D (dominant) while the other foot was defined as ND (nondominant) (Figure 1).

Change of Direction Deficit Calculation. Change of direction deficit was calculated for dominant and nondominant limbs using the following formula: 505 mean completion time – 10-m mean sprint time (12,34,36). As previously stated, the 10-m sprint time was taken from the 20-m sprint (10–20 m best split time).

Statistical Analyses

Mean ± *SD* values were calculated for all variables. Independent samples *t*-tests were used to compare the differences between the 2 maturational groups for the asymmetry index of the 505 test and the asymmetry index of CODD. Paired samples *t*-tests were used to compare the differences between the CODD asymmetry index and the 505 test asymmetry index for the entire sample. Effect size (ES) was calculated and interpreted as trivial (<0.19), small (0.20–0.59), moderate (0.60–1.19), large (1.20–1.99), or very large (2.0–4.0) (19). In addition, 95% confidence intervals (95% CIs) were included. The reliability of the 505 and 20-m tests was assessed by means of the intraclass correlation coefficient (ICC).

Results

No significant differences were found between the pre-PHV group and post-PHV group regarding their respective asymmetry indexes of the 505 completion time (−3.49 ± 2.49% vs. −3.49 ± 2.46%, $p = 0.994$, ES = 0.02). Likewise, the pre-PHV group and post-PHV groups showed no significant differences regarding the value of the asymmetry index of CODD (−8.21 ± 5.95% vs. −7.37 ± 5.12%, $p = 0.539$, ES = 0.15).

Significant differences were demonstrated between the D and ND directions for the 505 completion time ($p < 0.001$, ES = 0.56). Furthermore, significant differences were displayed between the D and ND direction for CODD ($p < 0.001$, ES = 0.85). The asymmetry thresholds were defined as −3.98% for the 505 test and −8.99% for CODD. According to these threshold values, 24 of 76 subjects (31.5%) showed greater values than the asymmetry threshold of −3.98% for the 505 completion time, but only one of 76 subjects established an asymmetry greater than 10% (1.3%). Regarding CODD, although 24 of 76 subjects (31.5%) exhibited values greater than the asymmetry

Table 1
Mean ± *SD* values for all tested variables in both groups.*

Variables	Pre-PHV (*n* = 45)	Post-PHV (*n* = 31)	ES (CI)
505 D (s)	2.68 ± 0.15	2.55 ± 0.15†	−0.91 (2.59 to 2.67)
505 ND (s)	2.77 ± 0.16	2.64 ± 0.14†	−0,93 (2.68 to 2.76)
Asymmetry index 505 (%)	−3.49 ± 2.49	−3.49 ± 2.46	0.00 (−4.07 to −2.92)
CODD D (s)	1.16 ± 0.10	1.21 ± 0.10†	0.48 (1.15 to 1.20)
CODD ND (s)	1.25 ± 0.11	1.29 ± 0.11	0.39 (1.24 to 1.29)
Asymmetry index CODD (%)	−8.21 ± 5.95	−7.37 ± 5.12	0.15 (−9.19 to −6.56)

*505 D = completion time during the 505 test (dominant foot); 505 ND = completion time during the 505 test (nondominant side); CODD = change of direction deficit; Asymmetry index 505 = difference (%) between 505 D and 505 ND; Asymmetry index CODD = difference (%) between CODD D and CODD ND; ES = effect size; CI = 95% confidence interval.
†Significant group differences ($p < 0.05$).

threshold of −8.99%, 20 of them had asymmetries greater than 10% (26.3%). The CODD asymmetry index values were significantly larger than the 505 asymmetry index values (−7.88 ± 5.61% vs. −3.49 ± 2.46%, $p < 0.001$, ES = 1.09). The reliability of the 505 test (ICC D: 0.72 [95%CI: 0.54–0.89]; ICC ND: 0.70 [95%CI: 0.51–0.90]) and 20-m (ICC: 0.82 [95%CI: 0.61–0.92]) test were considered high (Table 1).

Discussion

This study aimed to examine whether biological maturation can affect COD asymmetries in young soccer players. The results showed no differences between the pre-PHV and post-PHV groups regarding the asymmetry index of CODD and the 505 completion time. In addition, significant interlimb asymmetries were detected between the D and ND in CODD and during the 505 test completion time. However, the asymmetries based on CODD were greater than the asymmetries of the 505 test.

To the best of our knowledge, this is the first study that attempted to examine the influence of maturational status on COD asymmetry based on CODD and 505 completion time. The current study revealed no influence of maturational status on the 505 test asymmetry index. This is in agreement with the study of Madruga-Parera et al. (28) conducted on young tennis athletes. The researchers recommend the implementation of measures other than completion time for the optimal assessment of COD asymmetries. CODD is an index that can effectively isolate COD ability (36), and, in this way, it seems like a rational approach to interpreting CODD asymmetries to optimally assess COD asymmetries. Nevertheless, an unexpected result of the current study was that maturation stage did not have any effect on the asymmetry index of CODD. As stated by Lloyd and Oliver (21), the motor control of the emergence of interlimb asymmetries is impaired during the adolescent growth spurt—as a consequence, greater-than-normal interlimb asymmetries can arise during this period.

This condition was partially confirmed in this study because significant interlimb asymmetries were detected in both groups considering CODD. However, the values were not significantly different between the 2 maturational groups. The method of classifying the groups in the current study may have contributed to this finding. Given that the likelihood of significant limb asymmetries increases during the growth spurt, implementing a group consisting solely of athletes with an age around PHV (circa-PHV) could reveal greater asymmetries and, consequently, an effect of maturation on limb asymmetries. Another conceivable explanation is that the nature of COD does not favor the emergence of excessive asymmetries, and thus, the maturation process differentiates these asymmetries relatively little.

Based on this finding, it can be suggested that interlimb asymmetries observed during COD tasks are probably established early in an athletes' lives. Moreover, the actual recommended general training programs (applied in most soccer clubs) might attenuate the asymmetries expected along with the maturational status (17,38). Therefore, interventions to reduce asymmetries in COD should be performed with soccer players during the prepubertal phase to increase neural plasticity and maintain it throughout their childhood and adolescence, thereby reinforcing the regular transition to an elite competitive level and reduce the risk of injury (21).

Asymmetries between D and ND limbs observed during the 505 test were observed in young soccer players in the current study. This is in line with several previous studies that displayed significant interlimb asymmetries in COD ability (10,18,41). The same finding was observed for CODD, corroborating 2 previous studies (8,12) that attempted to assess interlimb asymmetries using this parameter. This finding indicates the development of increased leg dominance and highlights the cumulative exposure of soccer-specific training sessions and competitions. Therefore, it could be speculated that interlimb asymmetries in soccer players appear due to the asymmetrical nature of soccer because of repeated kicking movements and multidirectional turns are typically performed during practices and games (7,31). Moreover, because of laterality, one side of the body is preferentially used when performing a motor task, resulting in a more skilled dominant limb and promoting asymmetrical movements (42).

The results presented here showed a significant difference between CODD and 505 test asymmetry index values. Only one of the 76 subjects (1.3%) demonstrated asymmetry greater than the functional asymmetry threshold of 10% during the 505 test. Conversely, 20 of 76 subjects (26.3%) showed greater-than-normal asymmetry for CODD. Similar findings were previously reported in a study conducted in young team-sports athletes (12). The higher values of the CODD asymmetry index in comparison to the 505 test asymmetry index may be explained by the absence of the influence of linear speed in CODD, which could mask the actual interlimb asymmetries' percentage in COD performance (36). Nevertheless, it should be noted that part of this difference is due to the CODD values themselves, which are lower than the total time, thus providing a greater asymmetry index. The ability to be equally competent with both limbs in a variety of tasks provides an extra advantage in multidirectional sports (12). Hence, practitioners should consider using the CODD when assessing interlimb asymmetries in COD performance, as CODD may accurately detect interlimb asymmetries in COD ability because it can effectively isolate the actual time spent performing the turning movement (34). A more accurate evaluation method of COD asymmetries (i.e., an analysis of technical and biomechanical discrepancies in both turning directions) may offer the possibility of implementing more 'targeted' training approaches in an effort to optimize interlimb symmetry in turning actions during a soccer game. At the same time, a comprehensive evaluation approach of different deceleration strategies, owing to greater values of braking forces during the penultimate foot contact (when compared to the final foot contact), is correlated with better performance in 180° turns (11). Such an approach also enhances the factors that influence the efficient execution of changes of direction (trunk position, center of mass, height, knee flexion during the deceleration phase, and arm action) (33). Thus, this approach can significantly improve interpretations of turning movement deficiencies.

Further research is required for the identification of CODD asymmetries using different turning angles, athletic populations, and training periods. In addition, an analysis of CODD asymmetries through qualitative video analysis during the turning movement would contribute to the understanding of the technical components that form excessive CODD asymmetries. Finally, an isokinetic evaluation of lower-limb muscle strength would aid the establishment of correlations between lower-limb muscle strength and CODD asymmetry index.

In summary, the stage of biological maturation does not differentiate the percentage of interlimb asymmetries in COD ability, although a directional dominance in young soccer players is apparent during the developmental years. Thus, strategies to reduce asymmetries in COD should commence in pre-PHV soccer players because prepubescence seems to be the optimal period to implement motor control programs, including some basic COD techniques (21). The implementation of CODD as a measure for identifying COD interlimb asymmetries might be preferred to the asymmetry index based on the 505 test completion time because it more accurately assesses the COD ability and its emerging asymmetries.

The main limitation of this study was the classification of the subjects into 2 different groups. It would be probably more suitable to assess differences between players of 3 different maturational statuses of (i.e., pre-PHV, circa-PHV, and post-PHV) regarding interlimb asymmetries. Nevertheless, there is no consensus among studies regarding the exact cutoff points used for maturational status assessments. As an additional limitation, this study's inability to control the amount of effort that subjects applied during the testing procedures should be considered.

Practical Applications

Considering the unilateral nature of soccer and the importance of COD ability during a game, it would be desirable to put the proper amount of emphasis on optimizing this ability. In light of these results, the application of CODD is recommended as a measure to assess the COD ability level and its arising asymmetries because the influence of linear speed can be neglected with CODD. Assessing COD asymmetries using completion times produces a lower percentage of asymmetry index than CODD. As such, the actual value of the asymmetry index might be underestimated. It seems reasonable to assume that asymmetries emerge from a very young age, and as a result, the implementation of a suitable training intervention that targets the elimination of interlimb asymmetries is recommended as early as possible. Finally, neuromuscular training exercises, such as jumping exercises (with an emphasis on landing mechanics) and balance and muscle strength exercises, are also suggested.

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