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Digit Ratio and its Influence on Physical Performance: A Literature Review

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ABSTRACT

Prenatal androgen exposure has much importance in organizational questions in the human body. With it, the development of the human being is possible physically, behaviorally, and psychologically, in addition to allowing the detection of sports talents. To measure this exposure, the digit ratio (2D:4D) is the most used tool in academic papers. Using the length of the index finger and ring finger, this value can be translated indirectly in a simple way to understand. As the cardiovascular system is the main affected by fetal testosterone, sports which involve the physical endurance generally present a very significant relation with the marker digit ratio. Besides involving performance, the digit ratio can present relation with individual aggressiveness. Using a good quantity of studies already realized, it follows that digit ratio can really correlate its values with physical performance in a variety of sports, especially in predominantly aerobic modalities.

Introduction

Physical performance is constantly improved by new training methods, physical structures more suitable and enabled for an athlete approach, or by the improvement in the detection of sports talents. In addition to understanding factors such as physical training, physiological and anthropometric properties and psychological factors, a determination of a specific physical profile according to a sporting modality may represent an important aspect in the identification and development of sports talents [1-4]. Within the patterns, frequently, certain anthropometric measurements are used, among them the digit ratio or 2D:4D. The digit ratio is an indirect marker of prenatal androgen, which contains information on the amount of exposure to testosterone and estrogen in a window of the fetal development period between the eighth and tenth week of gestation [5]. This exposure may affect several areas of the individual, such as the brain, skeleton, muscles, and circulatory system and behavioral [6,7].

For the evaluation of its values, the 2D:4D uses the ratio of the annular finger and indicator, of the same hand, to analyze the individual's level of exposure to prenatal testosterone in relation to estrogen. So, the lower the value obtained from this ratio, the higher the level of exposure to prenatal testosterone. As their values do not change significantly throughout life [8] and are not related to age or physical factors (height, weight or body mass index), they can be applied to any individual [9], becoming a marker with global application. From this, several studies have analyzed the relationship between the level of androgens and the capacity of the cardiovascular system [10,11]. It is verified that in all the sports modalities, there is a great dependence of a developed cardiovascular system, with this, the objective of the present revision was to verify the validity of the effects of exposure to prenatal testosterone, using the marker digit ratio in the physical sport performance.

Methods

To perform this literature review, two electronic databases were consulted: PubMed and ScienceDirect. There were no language delimitations or date of publication. The main keyword used to conduct the search was digit ratio with Boolean operator AND and the secondary words: running, endurance, speed, sprint, aerobic and agility. To limit the acquisition of too much material that would not address the theme, the fields where the descriptors appeared were limited in: title, abstract or keywords. The search resulted in 22 articles (5 on the Science Direct database and 18 on the PubMed database). Three studies were excluded because used in their sample animals and not humans, and one was excluded because the study that did not address physical performance issues. Therefore, for the formulation of this review, 18 original articles were used.

Results

Pre-Natal Androgen and Their Modifications

Great levels of fetal androgens, especially testosterone, promote the development and maintenance of various capacities, such as resistance, rhythm, velocity, better visuospatial abilities [12], muscular hypertrophy [13], increased strength [14,15], decrease in fat body mass, increase in hematocrit, reduced reaction times [16], preparedness for engaging in stressful situations and sports [17] and especially the promotion of an efficient cardiovascular system [10,11].

According to Manning et al. [18], this is due to adjustments made by exposure to prenatal androgen, in characteristics that influence physical resistance and the aerobic component, such as running resistance, running economy, increased maximal oxygen uptake (VO2max) and improved vascular components [19,20].

On the other hand, valences that do not involve resistance are not so well covered by prenatal testosterone exposure, such as strength or potency [21]. The digit ratio was able to explain variations of 2% in speed sprints [21] and even 10% in sports that require a combination of strength and aerobic capacity [17]. These values are still too small compared to the 25 to 30% variation in the performance of medium- and long-distance athletes [18,22]. The analysis of the digit ratio can also be related to changes observed in behavioral scope. Decreased values of 2D:4D may cause changes that influence performance, such as increased confidence [23], aggressiveness [24,25], competitiveness [26] and dominance [27].

A model proposed by Geschwind & Galaburda [28] also suggests that prenatal testosterone tends to slow the development of certain areas of the left hemisphere of the brain, while favoring the right. As men generally have higher levels of testosterone, brain maturation eventually favors right hemisphere skills [29]. This pattern of neurological development may be advantageous for physical activities by predisposing and stimulating the athletic ability of the individuals [30].

Relationship with Aggressively

In addition to influencing organizational situations previously mentioned, the digit ratio presents concrete evidence of its mediation in the sensitivity to the testosterone itself throughout the life cycle of the individual [31]. Despite presenting a relationship with the sensitivity and stimulation of the hormone, there is no evidence for a strong association between 2D:4D and circulating testosterone levels. In the Manning et al. [32] study, a correlation was found between this level, however, subsequent reviews with larger samples concluded that the association was weak or null [22,33].

Hill et al. [34] and Kilduff et al. [31] showed that left-right digit ratio values were shown to be a marker for the increase of free testosterone levels in challenging conditions (physical, aggressive or sexual), where the lowest values had higher levels of free testosterone. So, if the hormone is increased in stressful situations and 2D:4D is a predictor of sports performance, and then it can also predict this "activation" of testosterone during physical and aggressive situations [35]. It is assumed that these testosterone peaks can be reserved for relevant situations, including sports competitions [27,36], aggressive and sexual confrontations [37,38]. Increases in free testosterone levels may occur immediately before or during physical challenges such as football matches [27], tennis [39] and judo competitions [40].

Other Variables Associated with Digit Ratio

Manning & Taylor [17] obtained fantastic results for the solidification of the digit ratio as a predictor of physical performance. In a study with 304 professional soccer players active or retired at various levels (international, first, second and third leagues, starter, reserves and juniors) several considerations were made: (I) professional players obtained lower values of 2D:4D than control groups that reflected the population mean; (II) titular players have lower digit ratio values compared to reserves and juniors; (III) players of international level had lower value of digit ratio when compared to players who did not reach that level; (IV) in professionals of international level who have already finished their careers, lower value of difference right-left (Dr-l) was associated with larger numbers of international apparitions; (V) there was a general increase in 2D:4D values starting from international players towards the less disputed leagues.

Several researches show that athletes of different sports modalities have lower values of digit ratio when compared to the general population. In a study by Moffit & Swanik [6], football and gymnastics athletes showed these results with high levels of significance ($p = 0.000$ and $p = 0.001$, respectively). Kabbadi players (similar to rugby) also have a lower value of 2D:4D compared to the control group (population in general, non-athlete) [41]. The same situation was observed in women, where amateur athletes have lower values of 2D:4D compared to women not engaged in sports [42].

Manning [43] found in a sample of 71 men athletes, from English clubs, who regularly trained and competed in the 800m and 1500m athletics modalities, a significant positive correlation between 2D:4DR (right hand) and 2D:4DL (left hand) with the times of the last three events performed by the individuals. In cross-country winter races, 117 men were evaluated (97 individuals for 800m and 67 for 1500m) in Manning et al. [44] studies. It was observed that the best times reported by the participants were significantly correlated with the values of 2D:4DR (right hand). Furthermore, in the 800-meter sample, the values were independent of the age factor and significant when compared to Dr-l.

Kociuba et al. [45] compared military and civilian career students. In the males, no difference was observed in the 2D:4D values between the two groups, but with the female sample, a clear and significant difference was observed, where the values of the right hand ($p<0.001$) and left hand ($p<0.01$) digit ratio was lower in the military group when compared to the civilian group. It is believed that women with higher physical abilities, higher levels of confidence and motivation may be more likely to choose challenging jobs, such as a military course. After military recruitment, selected students tend to present masculinized aspects more often, since the requirement for intense exercises becomes much greater over time [45]. In a sample of half-marathon runners, significant correlations were found between the 2D:4D values and the final race time in both men and women. Even with both significant values, the male sex ratio was stronger than that of the female sex [46].

The findings of Bescós et al. [9] show that the Dr-l digit ratio was associated with better current and past ranking positions, regardless of training intensity and years of fencing experience. Differences were found in that sport modalities: men who participated in the most aggressive modality - saber - had lower values of digit ratio when compared to the other two modalities - foil and sword. In the same study, it was also identified that left-handed athletes obtained lower values of digit ratio and also had better current and past rankings in the world ranking. The ethnicity, height, weight and years of international experience were considered in the research, guaranteeing higher levels of reliability.

In a study by Hill et al. [34] boys who have lower values of Dr-l reached higher levels of maximum oxygen consumption (VO2max), maximum oxygen consumption rate (vVO2max), and maximum lactate concentration (LAmax) than boys who have higher values of 2D:4D right-left. Age did not affect the results obtained. Tamiya et al. [47] found a negative correlation between the digit ratio value and percentage of victories and ranking in sumo wrestlers, suggesting that the higher level of prenatal testosterone may have positively influenced athletic progress in the modality. Even with weight and height control of the athletes, values continued to be associated with 2D:4D, showing that body mass had no significant effect on sumo performance as the digit ratio.

Although indications that the digit ratio affects more endurance sports, Manning & Hill [21] found satisfactory results in a sample of boys, where a positive correlation was observed between times of the sprints of 50 meters with 2D:4D values of the right hand. The performance was lower in athletes with higher values of digit ratio, and without influence of age, body mass index and maturation index, the correlation continued with significant values.

Conclusion

The present review shows the different approaches that the digit ratio can provide to the field of physical performance. Several methods analyzes and results can be achieved using 2D:4D. The studies presented above show that there is a relation between the athletic capacity of the individuals with their respective modalities, and a great part of the studies ends up reaching significant levels. When this value is not obtained, a trend is shown at least, showing the potential of 2D:4D in the scientific field. Even using a relatively low amount of articles, it can be concluded that the digit ratio or 2D:4D, is an important marker for predicting physical performance in some modalities. Longitudinal studies are needed to see if this question can be approached from sports initiation as a child, and whether these values actually confirm with the individual maturation.

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