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Section III – Sports Training

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Body Height and Swimming Performance in 50 and 100 m Freestyle Olympic and World Championship Swimming Events: 1908 - 2016

by
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There are scattered data showing an increase in the height of Olympic and World Championships swimmers. To identify a possible historical trend, a study of the height of 50 and 100 m freestyle medalists at the Olympic Games and the World Championships between 1908 and 2016 was undertaken. 370 swimmers (186 men and 184 women) were studied. A progressive increase in the height of men's medalists ($r = 0.49$, $p < 0.001$) was detected. With regard to women's medalists, an increase ($r = 0.383$, $p < 0.01$) was also found. To provide a sort of confirmation of this trend, a separate analysis of swimmers achieving new official swimming records, not included in the initial design of the study, was undertaken and a similar and also significant trend was seen in this case in both male and female athletes. This study confirms and greatly expands the observation of other authors, and raises the question of whether the increase in the stature of elite swimmers is simply a reflection of the increase in height of the general population or whether other factors, such as a possible role of training, should be considered. The ethical aspects of an early selection of swimmers perhaps based on the genetic profile of youngsters deserves careful consideration.

Key words: *elite swimmers, height, body mass.*

Introduction

The unusual body height of swimming medalists in recent years raises the question of its significance. It might be that this just reflects the rate of increase in stature of the general population along the years or that other factors, such as biases in the selection of talented swimmers, have also played a role. Furthermore, one might wonder whether body height could eventually be considered a predictor of performance. No studies have focused on these aspects and there are limited data on the evolution of this anthropomorphic trait. Khosla (1984) reported that female swimming finalists were about 3.5 cm taller than non-finalists at the Montreal Olympic Games in 1976. Later on, an analysis of the 200 m swimming events at the 1988 Seul Olympics showed a strong relationship between body height of the competitors and final time achieved (Chengalur and Brown, 1992). Also a study of the role of anthropometric variables in the swimming results of young female breaststroke swimmers revealed that body height was the most important one (Jagomägi and Jürimäe, 2005). The role of body height was also observed in a study of male 50 m freestyle swimmers in a local championship (Hlavaty, 2010). Finally, focusing on the evolution of size and shape in swimming, Charles and Bejan (2008) analyzed the data of men's world records for 100 m freestyle from 1912 to 2009 revealing proportionality between body height and speed. The aim of the present study was to evaluate in a much broader context the relationship between body height and performance in elite swimmers by means of data from men and women medalists in 50 and 100 m freestyle swimming. An overall view of the data provided by the Olympic Games and the World Swimming Championships would help clarify whether the increase in the stature of

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elite swimmers is simply a reflection of the increase in body height of the general population or whether other factors, such as a possible early selection of candidates to training, do play a role.

Methods

Participants

Medalists in 50 and 100 m freestyle events at the Olympic Games from 1908 to 2016 and at the World Championships between 1973 and 2015 were included in the study. Data about Olympic Games and Championship events and the number of medalists are presented in Table 1.

A total of 370 swimmers (186 men and 184 women) were considered in the study. Of them 84 men and 87 women had won two or more medals by participating in two or more events.

Data collection

The main anthropometric data analyzed in this study was body height (cm). Data about the participants at the Olympic Games and World Championships were obtained from freely available websites: IOC Olympic Games (2016), SR/Sports References (2016), the List of Olympic Medalists in swimming (men) (2016), the List of Olympic Medalists in swimming (women) (2016) and from the List of World Aquatics Championships Medalists in swimming (2016).

In order to contextualize the results of this study, and taking into account that the 50 and 100 m freestyle competitions can be considered speed courses, anthropometric data from athletes achieving the new official swimming records in the long course 100 m freestyle competitions from 1905 to 2009 were analyzed, to further define the role of the main variable studied. Data on body mass (kg) were obtained from the website: World Record Progression swimming 100 meters freestyle (2017).

Data analysis

Relationships between the year of the Olympic Games as well as of the World Championship event and body height of the medalists in 50 and 100 m freestyle events were evaluated by means of the Pearson Correlation, a simple linear regression test. Statistical significance of the regression equations was assessed by variance analysis once normality of the data had been established by the Shapiro-Wilk test. The *SigmaPlot* program (Systat Software Inc. California, USA) was used for all statistical calculations. Means ± Standard Deviations are presented in the results section.

Results

Men

As shown in Figure 1, there has been a progressive increase in the body height of men's medalists, as reflected by the modest, but significant correlation between the year of the event and body height ($r = 0.49$, $p < 0.001$); it is interesting to observe that this increase started to be particularly marked in the late sixties of the past century. Actually, mean body height of medalists in the 1908 - 1968 interval was 183.5 ± 0.9 cm, while it increased to 193.8 ± 0.5 cm in the 1972 – 2016 period. A detailed view of the increased presence of taller swimmers is presented also in Figure 1. As shown there, the sharpest increase was that of the 191-195 cm and of the 196-200 cm groups. Figure 3 shows the correlation ($r = 0.623$, $p < 0.001$) between the year when the record was achieved and body height of athletes obtaining these results.

Women

The body height of women's medalists along the years evaluated is presented in Figure 2. There was a modest, but significant correlation between these variables ($r = 0.383$, $p < 0.01$) and also in this case the increase was particularly marked in the late sixties and early seventies of the past century. Mean body height of medalists in the 1908 – 1968 period was 170.7 ± 1.8 cm, while it increased to 177.0 ± 0.6 cm in the years between 1972 and 2016. The appearance of body height above 181 cm is first seen in the eighties, as shown in the graph of the cumulative presence of different height groups (Figure 2). In the female swimmers achieving a new record, anthropometrical data were more dispersed than in the case of men, but there was still a statistically significant correlation ($r = 0.63$, $p < 0.001$) between the year of the record and body height (Figure 3).

Discussion

The results of the present study confirm and expand the observations of other authors about the increase in body height of elite swimmers in the last half-century and reinforce the notion that this trait is an important predictor of swimming performance. In 1984, Khosla reported the existence of appreciable differences in body height between women's finalists and non-finalists at the Montreal Olympic Games and a study of

collegiate swimmers found a correlation between performance in a 100 yard swim and body height in female participants, but not in males (Siders and Lukaski, 1993). Also a study of the 200 m events at the 1988 Seul Olympics found a strong relationship between body height and final time (Chengalur and Brown, 1992). More recently Zampagni et al. (2008) evaluated the role of body height in different swimming events which included 50, 100, 200,400 and 800 m freestyle runs of 135 elite master swimmers and found that body height was among the three best predictors in the short distance events. In a more limited study a correlation between body height and performance in a group of 50 m freestyle swimmers was also detected (Hlavaty, 2010).

Table 1

Medalists at the Olympic Games and World Championships (1908 – 2016) (freestyle)

Olympic Games			
	Games	Medalists	Anthropometric data not available
Men's 50 m	8	24	0
Men's 100 m	25	57	18
Women's 50 m*	8	25	0
Women's 100 m	24	56	16
World Championships			
	Events	Medalists	Anthropometric data not available
Men's 50 m	12	36	2
Men's 100 m	16	47	4
Women's 50 m	8	25	0
Women's 100 m	16	36	0

**4 Medals were awarded at Seoul 1988*

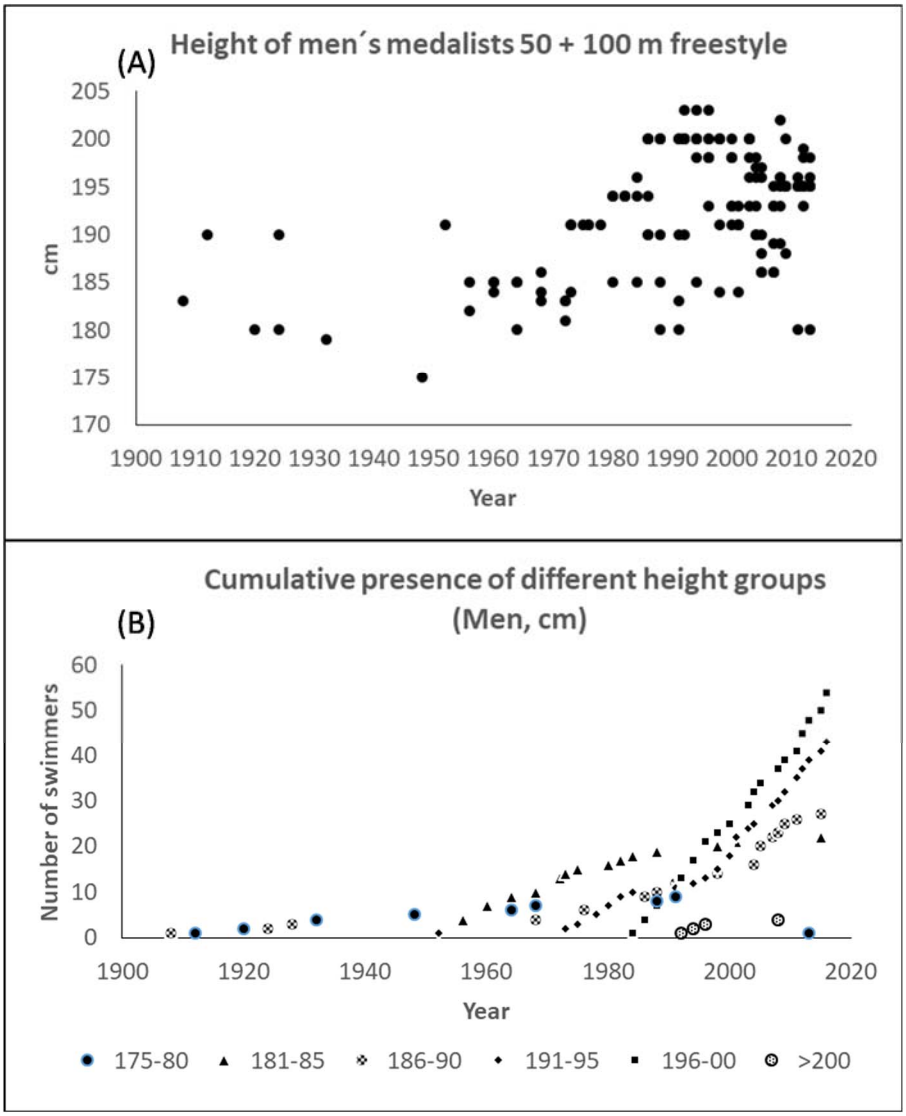

Figure 1

Body height of men's medalists (A) and cumulative values (B) of different height groups at the Olympic Games and World Championships (50 and 100 m freestyle) from 1908 to 2016

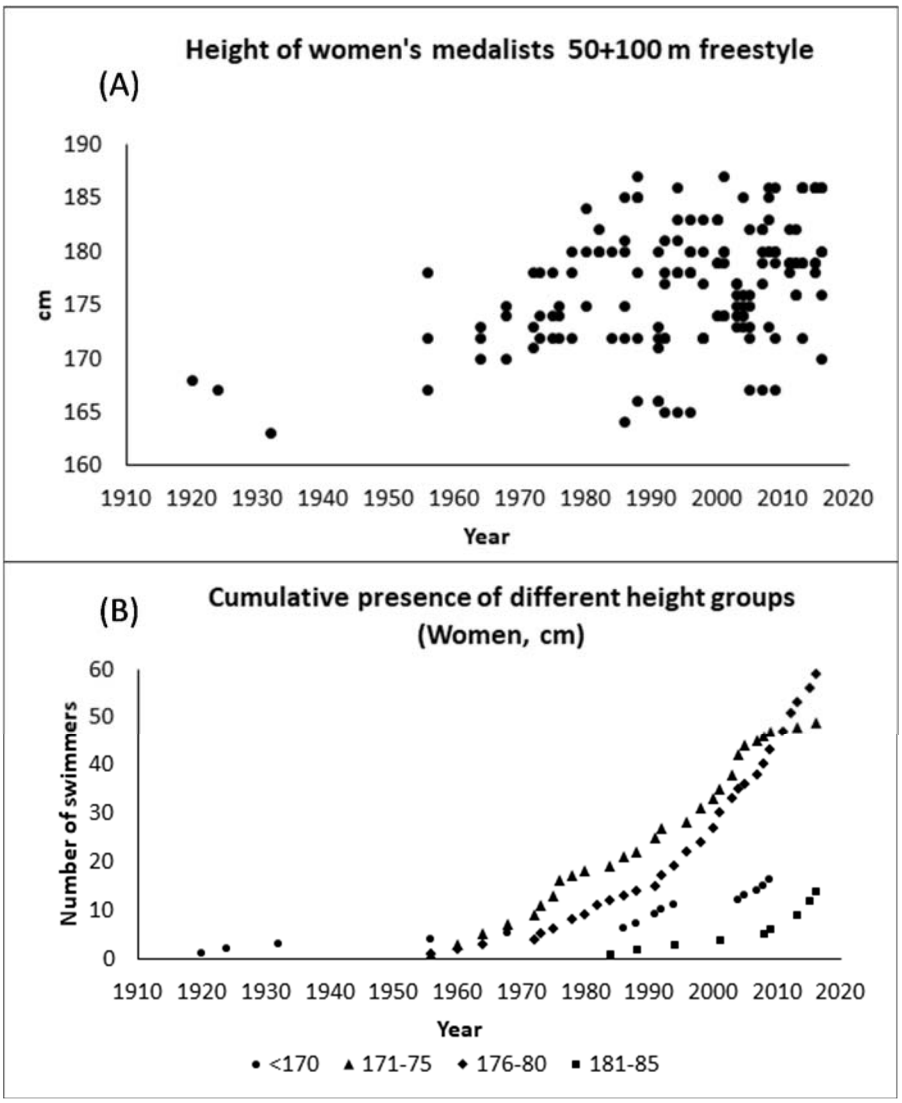

Figure 2

Body height of women's medalists (A) and cumulative values (B) of different height groups at the Olympic Games and World Championships (50 and 100 m freestyle) from 1908 to 2016

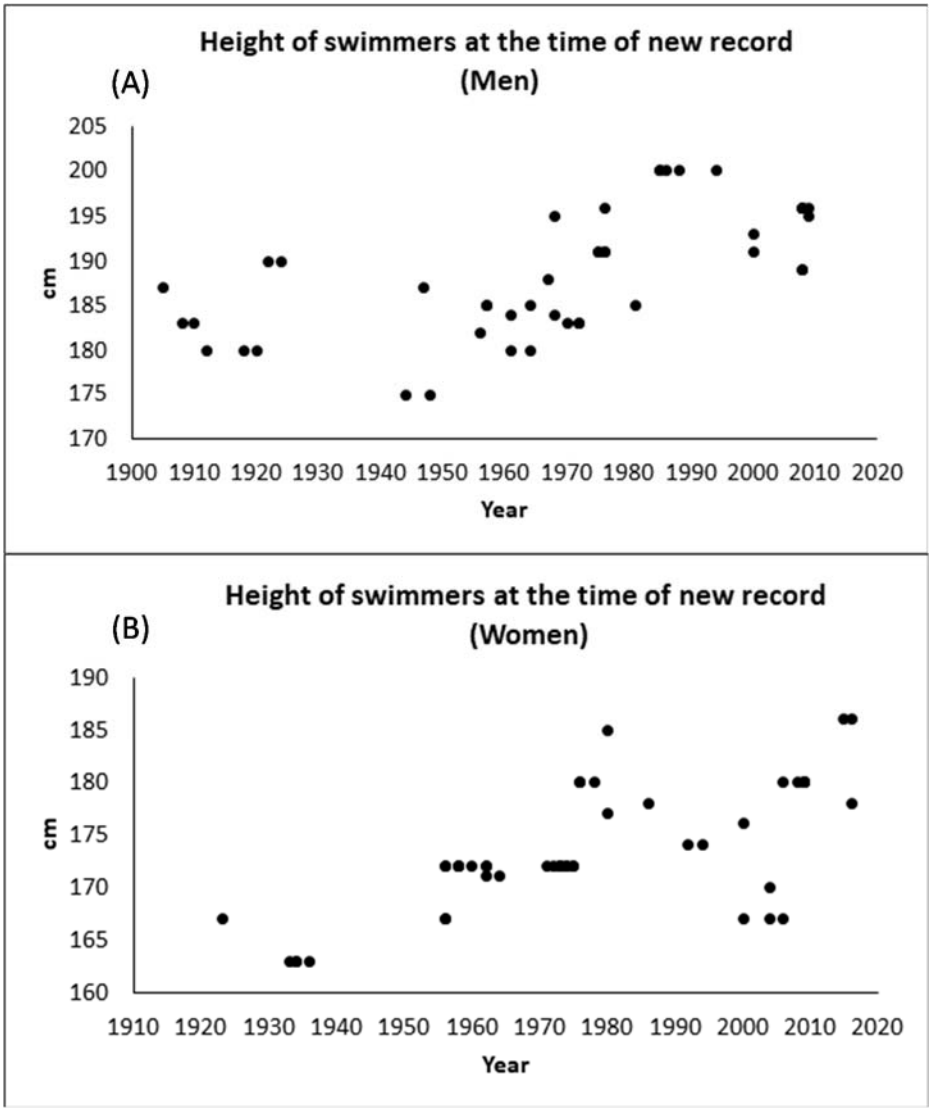

Figure 3

Height of male (A) and female (B) swimmers at the time of achieving a new record in 100 m freestyle

It is of interest to notice that the relationship between body height and swimming performance has also been observed in young swimmers in different studies. Thus, many years ago it was reported that young male and female swimmers aged 8 – 16 years were consistently taller, heavier and broader in their shoulders than the non-athletic same-age youth (Helmuth, 1980). Body height has been also shown to correlate with performance in 100 m freestyle swimming in adolescent boys (Lätt et al., 2010) and with estimated propulsive force in young female swimmers (Moura et al., 2014). A comparison of both genders indicated that performance at the 100 m freestyle swim correlated with body height in boys and girls, but in the girls the degree of association was markedly lower than in boys (Geladas et al., 2005).

A possible explanation for the increase in the stature of elite swimmers described in the present study would be that it is simply a reflection of the increase in body height of the general population. It has been shown that socioeconomic status influences growth (Baten and Blum, 2014; Freitas et al., 2007; Komlos, 2009; Malina et al., 1985;) and it is clear that in the second half of the 20th century a continuous increment in the gross national product in many countries has taken place. For example, data available from the United States show an increase in GDP of about 78% between 1948 and 1958 (US GD by Year, 2016). In this context, it is not surprising that body height of the general population has consistently increased in many countries during the past century (Roser, 2016), but it is not clear whether the pace of this growth can explain the somehow sudden increase in the stature of swimmers in the mid-sixties or the appearance of extremely tall swimmers in recent years. It is worth noticing that this marked rise of the stature is coincidental with the adoption of new training procedures (Murray and Karpovich, 1956; Thompson and Stulla, 1959), but no conclusion can be derived from this concurrence.

Finally it is possible to speculate that body height per se might have an effect on performance of swimmers, a notion that is reinforced by the data from the history of swimming records reported in the present study. In this regard, a study by Cochrane et al. (2015) showed that one of the variables that significantly contributed to the estimation of propulsive force was body height of the swimmers, and in a study of 237 boys ranging in age from 8 to 18 years (chronological age), body mass and height influenced the submaximal working capacity of the swimmers (Bouchard et al., 1976).

It is of interest to consider the mechanisms that could explain the association between body height and swimming performance. Most of the studies reporting this association show that a relationship also exists between performance and the arm span (Geladas et al., 2005; Lätt et al., 2010; MacLaren et al., 2002; Stager and Babington, 1997; Stanula et al., 2012) and it is well known that there is approximately a 1:1 ratio between body height and the arm span (Johnson and McPherson, 2005). An increased arm span in taller swimmers could explain their increased performance. Thus, in their study of the propulsive force of the arm in competitive male swimmers, Moura et al. (2014) found that it correlated with body height and the arm span, and Grimston and Hay (1986) reported a correlation between stroke length and the arm span in college swimmers. Finally, focusing on swim speed measurements, it is worth noticing that in their study of the speed in 100 m freestyle men's records, Charles and Bejan (2009) concluded that body height had an effect on speed.

The possible influence of a somatic trait on swimming, as well as on any other athletic performance, raises the question of the ethical consequences that it can derive. A study in 99 twin pairs suggested that different genes are involved in adolescent growth in the stature in both sexes (Beunen, 2000) and it cannot be forgotten that there is an increased interest in the elucidation of the genes involved in athletic performance (MacArthur and North (2005). As early as in 1997, Stager and Babington discussed the issue of somatic traits in the selection of potential elite swimmers. In the current era of continuous development of genetic screening tools, it is to be feared that genetic data might be used to select potential top swimmers at very early age, with many possible negative consequences. Further attention to the relationship between body height and swimming performance seems therefore appropriate.

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