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In a context of morphological expansion of the general population, how do athletes follow such a pattern of anthropometric growth? Is there any relation to performance? Biometric data including mass, height, body mass index (BMI) and age were collected for 50,376 American athletes representing 249,336 annual performers playing in professional baseball, football, ice hockey and basketball. Distributions by mass in National Football League (NFL) players are described by periods. Field goals have been studied in relation to players' height in the National Basketball Association (NBA). Between 1871 and 2011, athletes from the four sports have increased significantly in mass, height and BMI, following a multi-exponential function series. Consequently, biometric differences between athletes and the general population are increasing gradually. Changes in the mass distribution within the NFL show the emergence of a biometrical specificity in relation to the field position. At the professional level, performance remains structured around precise biometric values. In the NBA, a height-attractor at 201.3 ± 6.3 cm for the best scorers is invariant, regardless of the level of play. These results suggest that laws of growth and biometrics drive high-level sport and organise performance around the specific constraint of each field position. Discrepancies between some mass and height developments question the (disproportionate) large mass increase (relative to the height increase) during the 1980s and 1990s.

Keywords: *morphological changes, performance, National Football League, National Basket Association, National Hockey League, Major League Baseball*

Introduction

During the twentieth century, the general population in the United States of America, Europe and throughout much of the world has seen its mass, height, body mass index (BMI) and life expectancy increase (Floud, Fogel, Harris, & Hong, 2011). During this morphological expansion, the American population went through a considerable change from being the tallest in the world, to being among the most overweight and obese (Komlos & Baur, 2004). BMI serves as an energy indicator that can be interpreted in two ways: in the general population, it provides a measure of energy reserves and an estimate of adiposity, while it usually represents an indication of the power reserve related to lean mass among athletes (Nevill et al., 2010; Watts, Coleman, & Nevill, 2012). While all physical characteristics may not necessarily play a role in the selection process in professional sport; height and mass seem particularly important (Norton & Olds, 2001). Annual changes of height, mass and the calculated BMI can be analysed over more than a century in professional athletes in the four major sports (baseball, football, ice hockey and basketball) and compared to the US general population. The increase in height and mass of the general population directly impacts the evolution of morphology of athletes (Norton & Olds, 2001). Indeed, athletes experience the same phenomenon of morphological expansion as the general population (Floud et al., 2011). Meanwhile, sport performances also followed a large phenotypic expansion (Berthelot et al., 2012). As shown by Bejan and Marden (2006), in many species including humans, force, speed and power increase with mass: the fastest swimmers are also the largest (Charles & Bejan, 2009). These authors (Bejan, Jones, & Charles, 2010) showed that world records in running and swimming were performed by athletes with different centres of mass; a phenomenon that was predictable from physics laws.

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The morphologies of athletes during the twentieth century follow a selection process in relation to the constraints of their sport (Norton & Olds, 2001). The recruitment of increasingly rare morphologies occurs on a worldwide scale in different sports (Norton & Olds, 2001; Sedeaud et al., 2012). The morphological characteristics of athletes should therefore continue to increase and deviate from the average population and become more specific to their activity during the century (Norton & Olds, 2001). Indeed, body size provides a significant competitive advantage within many sports and in specific play positions (Sedeaud et al., 2012). But empirical evidence is lacking to show the influence of biometry on performance in disciplines with more extreme physiques (O'Connor, Olds, & Maughan, 2007), such as in the National Football League (NFL) or the National Basketball Association (NBA). Morphologies impact performance and create standards and threshold for selection. Indeed, athletes who compete in international competition generally display distinctive body size and shape compared with the normal population. The purpose of this study is (i) to compare secular changes in mass, height and BMI between athletes and the US general population, (ii) to observe the emergence of variability within these morphologies that could explain their selection for specific positions and (iii) according to these characteristics, to study the relationship between size and performance.

Methods

Data collection

After obtaining the approval of the Institutional Ethics Committee, biometric characteristics of 50,736 athletes were obtained from open-access sites www.sport-reference.com. Data correspond to the biometric characteristics and age of 50,376 athletes. Mass, height, BMI and age of all players who participated in at least one season of the NBA, NFL, National Hockey League (NHL) and Major League Baseball (MLB) from their respective initial year of creation until 2011 were collected. The 50,376 athletes were distributed as follows: 3453 basketball players from 1950 to 2011, 22,889 American football players from 1921 to 2011, 7213 hockey players from 1918 to 2011 and 16,821 baseball players from 1871 to 2011. As players perform over the course of several seasons, the 50,376 individual athletes represent 249,336 annual performers from the four different sports. We have included all players who have participated in one of these four major leagues since their creation.

All these data were compiled from the website www.sport-reference.com and cross-classified by various sources such as http://espn.go.com/nhl/, http://espn.go.com/nba/, http://espn.go.com/nfl/, http://espn.go.com/mlb/.

American general population. Mass, height and BMI of the US population aged between 20 and 30 years were compiled from the National Health Examination Surveys, from the successive National Health and Nutrition Examination Surveys between 1960 and 2002 (Kuczmarski, Flegal, Campbell, & Johnson, 1994; Ogden, Fryar, Carroll, & Flegal, 2004) and between 1999 to 2010 (Ogden, Carroll, Kit, & Flegal, 2012) and from the book "The Changing Body" for older statistics (Floud et al., 2011). These data were cross-classified by various sources (Finucane et al., 2011; Flegal, Carroll, Ogden, & Curtin, 2010; Komlos & Baur, 2004; Kuczmarski et al., 1994; Mokdad et al., 1999) and official website sources such as http://www.cdc.gov/nchs/, and reports such as the WHO Global Infobase Team: *The SuRF Report 2.*

Study design

Biometric evolution athletes in American sports. For each season, mean mass, height and BMI of all players in each discipline were obtained and compared to the American population. BMI was calculated as mass divided by squared height and rounded to the nearest tenth.

NFL. Changes in the mass distribution of all NFL players were observed over three 30 year periods: from the 1920–1921 season to the 1949–1950 season; 1950–1951 to 1979–1980; 1980–1981 to 2011.

NBA. In order to connect sports performance to biometric characteristics in the NBA we specifically analysed the last period: due to a plateau of height observed since then, we focused on competitive seasons from 1987 to 2011 (including 10,580 annual performers). We studied the maximum field goals according to the height of players and by deciles of game time. The first decile consists of 1058 players who spent the longest time on the floors per season; the last decile represents the 1058 NBA player with the shortest playing time. We have developed a decile treatment according to playing time to ensure that it represented all different positions in the same proportion: point guards, shooting guards, small forwards, power forwards and centres. We set a statistical threshold in order to verify that each point relating the maximum number of field goals and height was at least made up of 10 different players. Classes were adopted from 160.0 to 231.1 cm and ordered by inch (i.e. every 2.54 cm). This threshold was set in order to get representative data and discard values reached by single players in isolated groups of extreme height. A second degree polynomial equation was used to determine the optimal height at which players scored the maximal number of field goals for each level of performance.

Statistical analysis

For the US sports participants, changes in biometric parameters between decades were tested using analysis of variance, adjusting for age. Each series of yearly anthropometric parameters for each sport was fitted using a previously developed piecewise exponential model (Berthelot et al., 2008) that has been previously applied in different sports analysis (Berthelot et al., 2010; El Helou et al., 2010). In order to model the development of the two morphological parameters (mass and height), we used the following function:

$$y = a \cdot \exp^{b \cdot t} + c \qquad (1)$$

where y is the estimated morphological parameter at year t and a, b and c coefficients were estimated by a non-linear least squares method. This function was adjusted to different periods of time for each discipline and each parameter. The R^2 and root mean square error is given for each fitted period (Table I). Historical events (Berthelot et al., 2010; El Helou et al., 2010; Guillaume et al., 2009) and rule changes have determined different time periods for each sport since its beginning until the end of the 2011 season. The model (Equation (1)) was adjusted to each period of time. Concerning NBA data, we realised performance modelling of field goals as a function of height. The best performance by height is fitted by a 2nd degree polynomial function. The level of significance was set at $P < 0.05$. Statistical analyses were realised using dedicated statistical software packages, Statistica 7.1 and R 2.13.0.

Results

Secular trend

The increase in mean mass was 14.0 kg for NHL players between the 1918 and 2011 seasons (1.5 kg/decade), 22.9 kg for MLB players since 1871 (1.6 kg/decade), 14.2 kg for NBA players between 1950 and 2011 (2.3 kg/decade) and 24.8 kg for the NFL players since 1920 (2.7 kg/decade). The increase in mean height was 8.2 cm for NHL players (0.9 cm/decade), 8.2 cm for NFL (0.9 cm/decade), 13.4 cm for MLB (0.9 cm/decade) and 9.7 cm for NBA players (1.6 cm/decade), over the same seasons, respectively. Increases in mean BMI were therefore 1.4 $kg \cdot m^{-2}$ for NHL players, 1.3 $kg \cdot m^{-2}$ for NBA players, 3.3 $kg \cdot m^{-2}$ for MLB and 4.5 $kg \cdot m^{-2}$ for NFL players over the same period. Mean age was 26.3 ± 0.5 years in NFL, 26.4 ± 0.5 years in NBA, 27.1 ± 0.9 years in NHL and 28.2 ± 0.6 years in MLB.

Figure 1 (a) shows the change in the mean height of all athletes according to the seasons compared to that of the general population. For all athletes and for the general population, a stagnation of mean height occurred in the 1990s after a large widening of the athlete–population gap: in 1870, baseball players were 2.8 cm taller than the general population; in 2011, they were 11.9 cm taller. This widening gap is observed in all sports. NHL, NFL and NBA players were 2.7 cm, 6.7 cm and 20.2 cm taller, respectively, than the general population during their first season; for the 2011season they were 10.1 cm, 11.9 cm and 24.9 cm taller, respectively.

Table I. R^2 and root mean square error (RMSE) for each period fitted in Figures 1 (a) and 1 (b).

	Courbe1		Courbe2		Courbe2	
Height	R^2	RMSE	R^2	RMSE	R^2	RMSE
NBA	0.9628	0.4964				
BASEBALL	0.9499	0.4241	0.9849	0.2468		
NHL	0.9015	1.0223				
NHL2	0.8078	0.506	0.8644	0.4676	0.9477	0.257
NFL	0.888	0.6333	0.8466	0.3194		
	Courbe1		Courbe2		Courbe3	
Mass	R^2	RMSE	R^2	RMSE	R^2	RMSE
NBA	0.8148	0.8811	0.8987	0.8666		
BASEBALL	0.9227	0.5439	0.9828	0.2645	0.7447	1.7082
NHL	0.8871	1.4836				
NHL2	0.8372	0.3422	0.936	0.5433	0.8994	0.6556
NFL	0.8562	1.1566	0.8823	0.9128	0.8894	1.2734

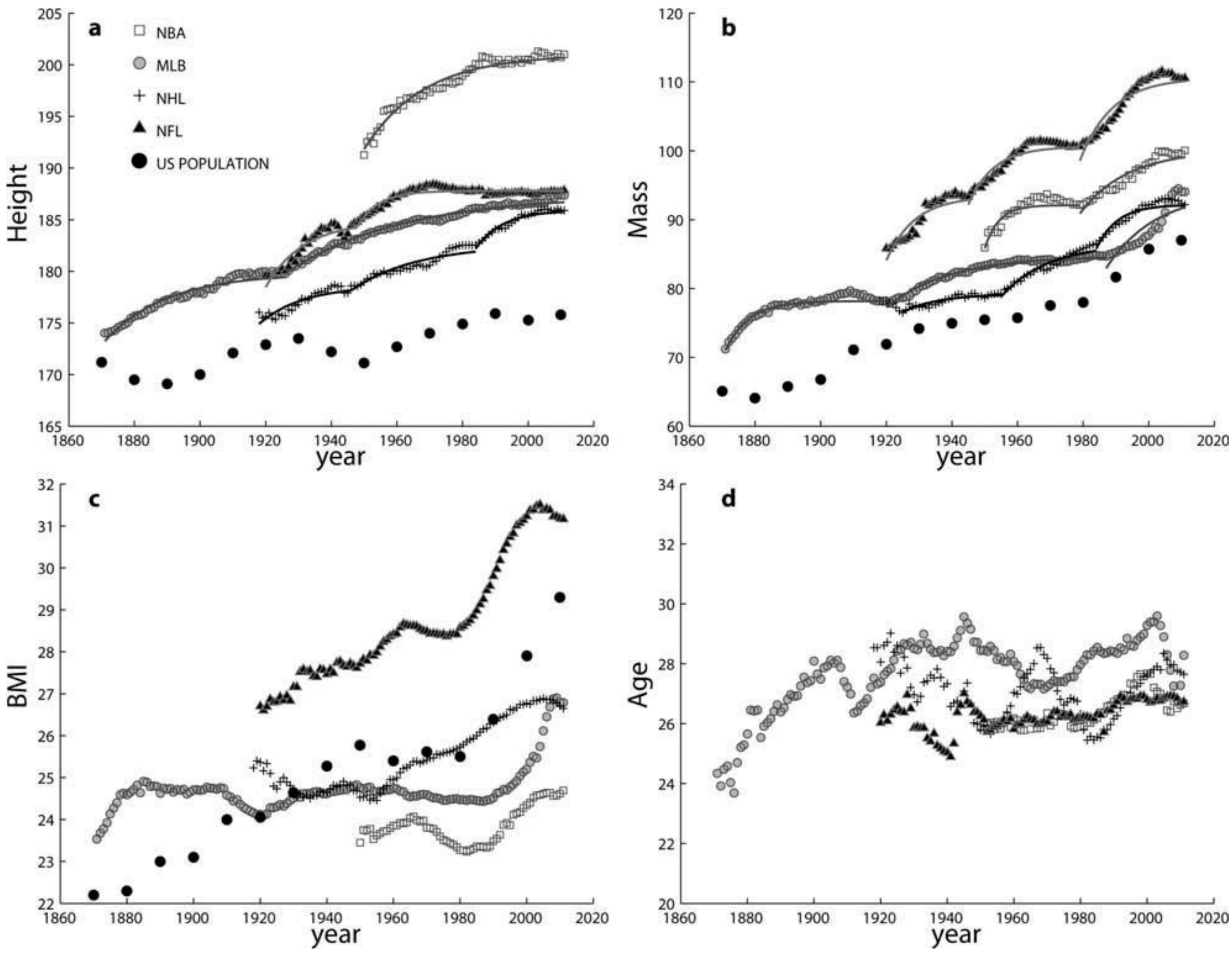

Figure 1. Evolution of (a) height (in cm), (b) mass (in kg), (c) BMI (in kg · m^{-2}) and (d) age (in year), represented by mean of all NBA, NHL, NFL and MLB players.

Figure 1 (b) shows the change in mean mass of all athletes according to the seasons compared to that of the general population. A period of synchronised growth started in the 1980s: between 1980 and 2011 the mean mass increased by 6.4 kg for NHL players (2.1 kg/decade), by 9.4 kg for NFL (3.1 kg/decade), 7.9 kg for NBA (2.6 kg/decade) and by 9.7 kg for MLB players (3.2 kg/decade). Over the same period, while the NFL players became heavier by 9.4 kg without increasing in height, MLB players expanded their masses by 9.7 kg for an increase of only 1.7 cm. The gap between the mean mass of athletes and the population mass also widened. In 1920, NFL players were 13.9 kg heavier than the general population, while the difference was 23.6 kg in 2011. Similarly, MLB and NBA players were 6.1 and 10.5 kg heavier during their first season, but 7.1 and 13.1 kg during the last one.

Figure 1 (c) shows the change in the mean BMI of all athletes according to the seasons compared to that of the general population. From 1980, a major increase for all athletes is observed. From 1980 to 2011, the NFL players increased their mean BMI by 2.6 kg · m^{-2}. Similarly, basketball, baseball and hockey players presented a BMI of 23.3 kg · m^{-2}, 24.5 kg · m^{-2} and 25.7 kg · m^{-2} during the 1980 season; it reached 24.7, 26.8 and 26.6 kg · m^{-2} during the 2011 season, respectively.

NFL

Figure 2 (a) illustrates the development of the mass distribution among NFL football players on three periods of approximately 30 years. Over the period from 1920 to 1949 (P1), the football players' masses are distributed normally. During the 1950–1979 period (P2), three peaks arise: at 90, 105 and 115 kg. During the most recent period (P.3), 1980–2011, the first peak stands at 95 kg, the second at 110 kg, the third at 120 kg and the last at 140 kg. Over the entire period, there is a large broadening of the mass distribution. Figure 2 (b) illustrates the mass distribution of NFL football players (grey surface area) compared to the general population: the distribution

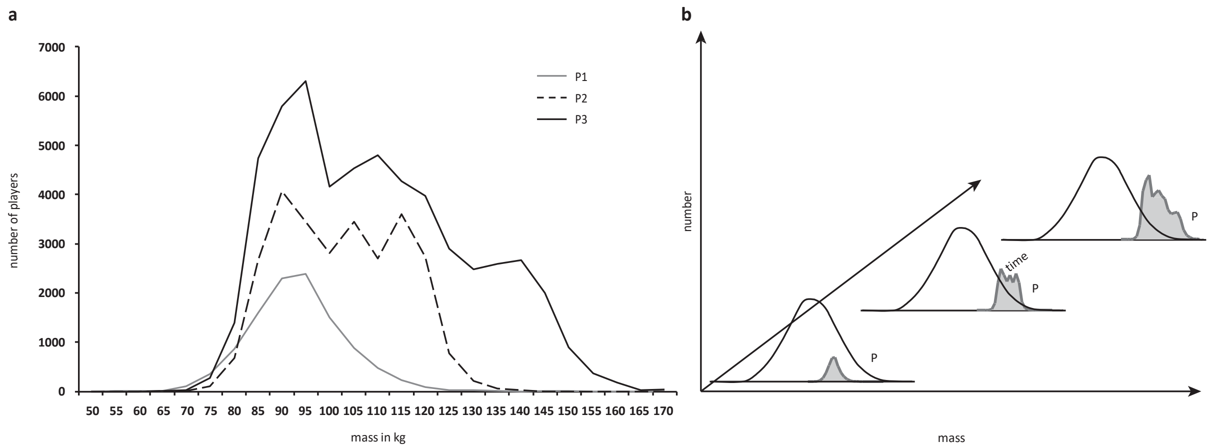

Figure 2. (a) Changes in mass distribution of all NFL players by periods. (b) Conceptual changes in mass distribution of all NFL players by periods compared of general population. P1: period from 1920 to 1949; P2: period from 1950 to 1979 period and P3: period from 1980 to 2011 period.

of the population shifts to the right (heavier people) but athletes also become much heavier and deviate more and more from the general standards.

NBA

Figure 3 shows the maximum number of field goals per NBA season according to height. The mean height of the top scorers (the "height-attractor") is situated at 201.3 ± 6.3 cm (mean peak for each polynomial function modelled for all deciles). Indeed, this relation for the first decile was determined by the following equation: ($y = -0.5298x^2 + 206.73x - 19{,}326$, $R^2 = 0.65$), for a maximal number of field goals of 1098 in the 1987 season realised by M. Jordan (himself measuring 198 cm in height). This height-attractor is constant regardless of the level: it is similar for all deciles (Figure 4). Even for NBA players spending less time per season on the floor, top scorers have a similar height optimum. From the first to the last decile, the group of players between 190 and 208 cm scored the same percentage of points in their category (50.3% of point scored in the first decile and 51.6% in the last decile).

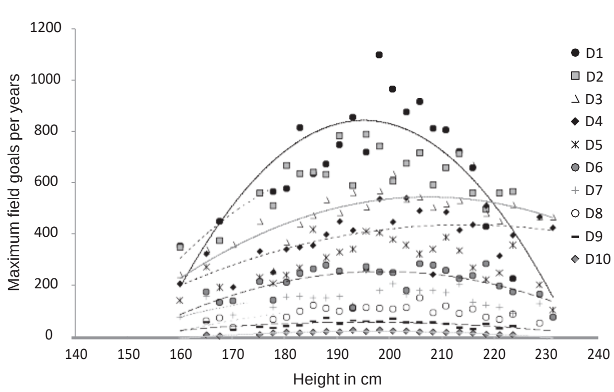

Figure 3. Maximum field goals per year as a function of height during the 1987–2011 NBA seasons according to playing-time deciles.

Discussion

Secular trends

We show that between 1871 and 2011, professional athletes in four American sports leagues display large increases in mass, height and BMI assessed by multi-exponential series. This trend is observed in different sports at different periods (Kraemer et al., 2005; Malina, 1972; Norton & Olds, 2001; Sedeaud et al., 2012; Sedeaud, Vidalin, Tafflet, Marc, & Toussaint, 2013). These increases are to some extent driven by the growth rates observed in the general population (Flegal et al., 2010; Kuczmarski et al., 1994; Ogden et al., 2004, 2012), and a strong selection process exacerbates these trends in professional sports.

The study shows a significant mass expansion within these sports with a synchronisation of slopes, including a large increase starting in the 1980s. This confirms the trends of substantial mass gains observed in sports (Norton & Olds, 2001) especially in the NFL (Anzell, Potteiger, Kraemer, & Otieno, 2013; Kraemer et al., 2005; Malina, 1972). The maximisation of body size and the quest for "super-physiques" are inherent to the NFL selection, expressed by greater demand for bigger athletes (Anzell et al., 2013). The increases in mass in the four sports can also be explained by the increases and diversification in the training load (Anzell et al., 2013) and strength programmes (Ebben & Blackard, 2001; Simenz, Dugan, & Ebben, 2005) coupled with specific nutritional strategies (Anzell et al., 2013;

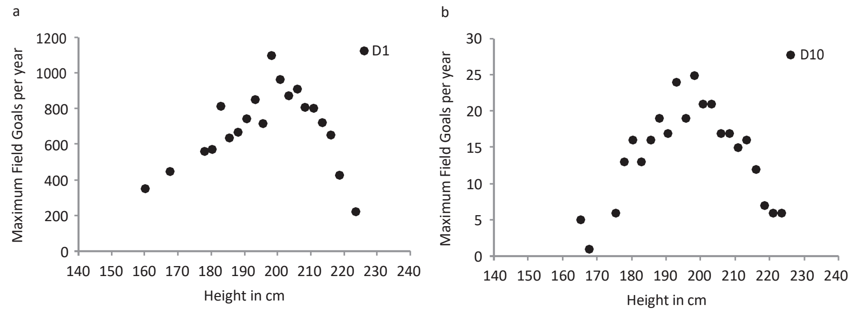

Figure 4. Maximum field goals per year in function of height during 1987–2011 seasons for the first and last playing-time decile.

Malina, 1972). Another possible explanation involves changes in the sports rules (Anzell et al., 2013) such as the “wedge flying”, or the prohibition of cutting (diving in the legs) during a drive blocking in the NFL. This requires players to come and support their teammates in their pushing blocks and requires more power. The facts that defensive players can raise their arms to block the ball, that a greater number of players are allowed in each team and that there are more rest periods during games may have also contributed to recruiting more massive players (Norton & Olds, 2001). The growth parallels observed in sports as different as baseball, basketball and hockey probably reveal common and deeper tendencies.

The study shows significant increases in the BMI of American athletes. We also observe some slope synchronisation with a stagnation between 1960 and 1980, similarly to what has been observed in the general population (Kuczmarski et al., 1994). However, even if the major BMI gains among the general population and athletes demonstrate synchronous increases, they do not reflect similar types of growth: in the general population, such a rise principally reflects increased adiposity, while in athletes, this increased BMI reflects a larger muscle mass (Nevill et al., 2010; Watts et al., 2012). Nonetheless, the recent shift in the population’s BMI shows a deviation from the healthy range, demonstrated by the optimal iso-BMI curve (Fogel, 2004). While a gain in fat among the population is well known to be directly associated with many adverse health consequences, substantial mass gains in athletes could also be detrimental in terms of injuries (Laurson & Eisenmann, 2007) or health risk (George, Kab, & Levy, 2003; Harp & Hecht, 2005).

Widening gaps

Athletes’ physical characteristics increasingly shift away from the general population. This widening gap highlights the selective component of professional sport (Sedeaud et al., 2013), targeted towards specific morphological characteristics as has been shown to occur in rugby union (Sedeaud et al., 2012, 2013) and other sports (Malina, 1972; Norton & Olds, 2001). Furthermore, during every period, athletes are, on average, taller and heavier than their non-athlete peers in the general population, a trend that remains consistent with previous studies (Norton & Olds, 2001; Sedeaud et al., 2013). The widening gap is observed in all sports (height and mass), despite the expansion observed in the general population.

Plateau effect observed in height-selected athletes

After significant gains in the early-to-mid-twentieth century, further increases in mean height were much smaller, and have stagnated since 1990 (Kraemer et al., 2005; Norton & Olds, 2001). This could be partly explained by the nutritional status (Floud et al., 2011). Transmission of optimal nutritional conditions for generations may have enabled the expression of maximum height for each individual and consequently, those of athletes selected from the general population. The 30-year stagnation in these especially tall (athlete) populations have similarities with the stagnation observed for the world record (Berthelot et al., 2008) and best world performances (Berthelot et al., 2010). Through height and mass increases, homothetic function (i.e. a function which preserves shape while changing scale) between world record and biometrics could model the high-level sport performance. Indeed, height and mass changes over the century follow the same piecewise exponential pattern observed in road cycling performance (El Helou et al., 2010), swimming, weightlifting or 50 km walk world records (Berthelot et al., 2008) or best performers in track and field and swimming events (Berthelot et al., 2010). Moreover, selective pressure occurs on the tallest athletes in different sports (Norton & Olds, 2001). Yet height stagnation trends first seen in NFL and NBA players during the 1970s and 1980s also occurred in MLB and NHL in the 2000s. Unlike morphological changes found in many sports (Norton & Olds, 2001; Sedeaud et al., 2012, 2013), these changes seem to stop. This may be due to an exhaustion of the selection process in a no-longer growing pool of the largest athletes or to a morphological optimisation.

Skewness between some increments

Consistent discrepancies between mass and height increases may also bring into question the potential influence of any performance-enhancing drugs that may have been used by some athletes. Such a discrepancy between the expected evolution of performance indicators had already been suggested in road cycling (El Helou et al., 2010). In fact strength training, nutritional follow-up and performance-enhancing aids are coupled among many players in order to increase muscle mass and strength (Anzell et al., 2013). In the Mitchell report (2007), several players suggested that half of major league players use anabolic steroids. In some positions among the NFL, it has been reported that this ratio may be as high as 90% (Yesalis, 2000), particularly among offensive and defensive linemen (Anzell et al., 2013). The annual report of the World Anti-Doping Agency (WADA) revealed a much lower number, close to 1% (128 of 18,402 baseball players, 68 of 5370 ice hockey players, 160 of 21,225 football players and 139 of 9575 basketball players were tested positive for performance-enhancing drugs) (World Anti-Doping Agency, 2010). Furthermore, despite this low percentage, it is almost universally accepted that the use of performance-enhancing drugs is the greatest problem in professional sports today (Norton & Olds, 2001). Through this broad estimate (1–90%), the truth probably lies next to a greater percentage, as the inconsistent mass gain compared to the small height increase reveals some discrepancies that are difficult to explain. The official WADA data may therefore only show the "tip of the iceberg", and could be supported by a great number of not controlled deviant behaviours. Through evidence and testimonies of widespread steroid use, the skewness of mass increase compared to height changes suggest, like Norton and Olds underlined in 2001 (Norton & Olds, 2001), that ergogenic aids have largely been involved. If skewness between height and mass increases can be useful to highlight atypicity (Berthelot et al., 2010), further research is required to validate the direct causes and consequences of these findings and potential use of illegal substances.

American football

During the first period, the normal distribution of mass shows lower variability between players by position. During the second period three peaks emerge, reflecting the specificity among field positions. From this period, the NFL established its status (first Super Bowl in 1967), bringing the teams to pay more attention to the choice of recruited players according to their strategic or tactical needs. In this second period, the first peak at 90 kg corresponds to the mean mass of wide receivers, corner backs and tell backs, mean mass evolution being consistent with previous results over the same period (Kraemer et al., 2005). Players in these positions are the fastest and very explosive. Wide receivers and tell backs carry the ball in attacks; they are able to change direction in a minimum of space and time. Corner backs are their defensive counterparts and therefore must ensure their coverage and follow them on the field explaining similar morphological characteristics. Full backs, linebackers, tight ends and defensive ends lie in the 105–110 kg range. These players are a little slower but very powerful. For example, the main objective of the full back is to provide a lead block for tight ends and clear the way against their defensive counterpart, the linebacker. The tight end is generally the tallest of these players, and he is necessarily powerful as he should be able to block a defensive line. The tight end is also fast because he can also get in track to catch the ball, so his physique is a mix between the wide receiver and the offensive line. The defensive end must lead the game inside the defence, it is because he must also have power qualities in order to compete against offensive linemen (OL). Linemen are represented in the 115–120 range. They are the heaviest players in the NFL (Kraemer et al., 2005), running over short distances 5–10 yards, sack (i.e. make a tackle on the quarterback behind the line of scrimmage before he can throw a forward pass), opening doors for runners or protecting their quarterback. Over the last period (1980–2011), the first peak around 95 kg gathers wide receivers, corner backs and tell backs (in the 2012 NFL Season data, the mean was 92.6 kg, personal data), than 110 kg peak represents defensive ends, full backs, tight ends and some more fit and athletic line players (confirmed by the 2012 NFL Season data, personal analysis: mean for these three positions 108.6 kg). In the contemporary period, data show another peak at around 120 kg which would include the defensive linemen and OL (confirmed by the NFL in 2012 data), these players became physically large because larger OL provide better pass protection for the quarterback in a team that might use a passing offence. The distribution highest peak at 140 kg includes defensive line and offensive line (2012 Season: mean mass 142.1 kg, personal data). Selective factors such as size requirement in football seem to be acting throughout the second period starting in 1950 with an increased degree of specialisation (Kraemer et al., 2005; Snow, Millard-Stafford, & Rosskopf, 1998).

Basketball

Another key result of this study is showing that a mean height (height-attractor) for best scorers is at 201 cm, a measure that does not vary according to the level of play. Taller individuals have an obvious advantage in this sport. Body height improves the execution of certain specific movements: taller players' shots have less distance to travel to the basket; they start out closer to the rebound, and their ability to jump higher yields a better chance of blocking shorter players' shots or achieving a lay-up or dunk. Indeed, physical attributes like height may constitute important prerequisites for successful participation in basketball (Ostojic, Mazic, & Dikic, 2006): the best point guards and small forwards are taller than the less good scorers (Ackland, Schreiner, & Kerr, 1997; Hoare, 2000). However, the relationship between height and field goals does not follow a linear trend. We show here that this relationship goes through an optimum. It is likely that this morphology better assembles the qualities required such as speed, jump, agility, dexterity or shooting skill while also drawing benefits from large size. This size also can be the best compromise to not only score behind the three-point line but also in mid-distance shoot or finished in a lay-up or dunk and optimise opportunities to score. It could be the best trade-off between different requirements in multi-objective optimisation problem (Shoval et al., 2012). Whatever the level of play (those playing the shortest or longest time) is, it seems that 201 cm is the height-attractor. Shooting guards and small forwards have a mean height at 201.9 cm (during this studied period). These players have a major role as scorers, and create more uncertainty among opponents by their ability to shoot over long, middle and short distances. On each side of this height optimum, we find that those closest to the attractor (i.e. the tallest of the small and smallest of the tallest) make more field goals. We also suggest a performance interval where players in a small range of height (190–208 cm) score more than 50% of all field goals, whereas the spectrum of height has a much larger range (160–231 cm). This does not imply that shorter or taller players do not score, but they score less. Indeed, scoring performance decreases as the distance from the optimum increases, and is maximised in a region rather than a single point (Shoval et al., 2012). A range from 190 to 208 cm could be a better trade-off for all tasks involved in basketball, and probably multi-interval performance, such as energy resources, physical skills or collective experience generate basketball performance (Ackland et al., 1997; Delextrat & Cohen, 2008; Ostojic et al., 2006). While an ideal physique is not sufficient for excellence, it largely contributes to it: the key is to find one's own optimal combination between all qualities that optimise basketball performance.

Conclusion

In conclusion this study shows a secular increase in mass, height and BMI of the four major US sports players following a multi-exponential function pattern. This tendency, however, seems to level off for height in both professional players and citizens in the general population. By comparing the progressions of growth laws, differences between certain biometric developments (height vs. mass) lead to questions about the behaviour that allowed these large mass increases between 1980 and 1990. Over the whole period, positions specificity arises based on anthropometric characteristics due to morphological expansion and enhanced selection.

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