Monitoring anthropometry and fitness using maturity groups within youth rugby league

Running Head: Anthropometry and fitness within maturity groups

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ABSTRACT

The purpose of the present study was to evaluate the anthropometry and fitness, and change in these characteristics over time, of youth rugby league players by using maturity status to determine annual categories instead of traditional chronological annual-age grouping. One hundred and twenty one male rugby league players were assessed using anthropometric (i.e., height, sitting height, body mass and sum of four skinfolds) and fitness (i.e., vertical jump, medicine ball chest throw, 10m and 20m sprint and multi stage fitness test; MSFT) measures over a 5 year period. Each player was classified into one of six maturity groups based on their maturity offset (Years from Peak Height Velocity; i.e., 1.5 YPHV). MANOVA analyses identified significant ($p<0.001$) main effects for maturity group for cross-sectional characteristics and longitudinal change in performance over time. Analyses demonstrated that more mature groups had greater anthropometric and fitness characteristics, except for endurance performance (MSFT -2.5 YPHV = 1872 ± 18 m vs 2.5 YPHV = 1675 ± 275m). For longitudinal changes in characteristics over time, a significant effect was only identified for height and sitting height ($p<0.05$). These findings provide comparative data for anthropometric and fitness characteristics and change in performance over time in accordance to maturity status within youth rugby league players. Classifying players into annual maturity groups may be an additional or alternative assessment method for evaluating anthropometry and fitness performance in adolescent populations. Further, tracking performance changes over time, especially in relation to maturation, may reduce the limitations associated with chronological annual-age grouping.

Key Words: Maturation, longitudinal, player assessment, talent identification, talent development

INTRODUCTION

The assessment of anthropometric and fitness characteristics of adolescent athletes is commonly used within research and practice across youth sports, with literature available that presents comparative data within such populations (e.g., rugby union, 25; soccer, 11; volleyball, 21). These anthropometric and fitness characteristics are often collected and analysed by strength and conditioning coaches to assist with talent identification and monitor the responses and development of physical characteristics in relation to various training programmes. Traditionally in youth sport contexts, players are assigned, compete and are selected within chronological annual-age categories (i.e., Under 13s) similar to educational systems. As this chronological annual-age grouping process is common, athlete characteristics are always presented, assessed and evaluated within such annual-age categories.

During adolescence, maturation (i.e., the timing and tempo of progress towards the adult mature state, 16) varies considerably between individuals of the same chronological age (4). As physical performance is related to biological maturation during adolescence (15,22), boys advanced in biological maturity are generally better performers in physical tasks (e.g., speed, strength, power) than their later maturing peers (17). Since maturation and chronological age rarely progress at the exact same rate (15), comparisons of characteristics using chronological annual-age categories, can lead to youths being (dis)advantaged due to their maturity status (2). These maturational (dis)advantages have resulted in the selection of relatively older (5) and earlier maturing (18,24,28) players to representative levels within youth sport. Although this relationship is apparent and it has been recommended to consider maturity status in the evaluation of performance for over 15 years (3), only recently have studies began to consider maturation in the evaluation of physical characteristics within youth athletes (30,32). Based on the effect of maturity on performance and selection within adolescent populations, it may seem more appropriate to consider individuals by maturity instead of traditional chronological annual-age grouping systems.

Alongside, presenting data within chronological annual-age categories, current research is predominantly cross-sectional with performance often only measured at one specific time point. Recent recommendations suggest monitoring performance longitudinally to assess the changes that occur in characteristics over time (34), which would allow the evaluation of the development of characteristics within and among youth athletes to be more easily identifiable (1). However, research observations tracking characteristics longitudinally within adolescent athletes are limited (6,36), especially considering maturational status (22,31).

Due to the physically demanding nature of rugby league, players are required to have highly developed fitness capacities of power, strength, speed, agility and aerobic power (8). Research to date in Australia (7,9,10) and the UK (30) has demonstrated increasing anthropometric and fitness characteristics across youth annual-age categories and the selection of earlier maturing players to talent development squads (i.e., Regional and National, 28). Due to the relationship between maturation, anthropometry, fitness and performance in youth rugby league this provides an ideal population to consider such characteristics by maturity status.

Therefore, the primary purpose of the current study was to evaluate the anthropometric and fitness characteristics within a rugby league academy by using maturity status to determine annual categories instead of traditional chronological annual-age groups. The second purpose was then to provide a longitudinal evaluation of the change in anthropometric and fitness characteristics in relation to maturity status.

METHODS

Experimental Approach to the Problem

Rugby league players aged between 12.8 and 15.5 years from an English Super League club's academy performed a testing battery at the start of each pre-season over a five-year period (2007-2012). Players were assessed on anthropometric (height, body mass and sum of four skinfolds), maturation (age at peak height velocity; PHV) and fitness (vertical jump, medicine ball chest throw, 10m and 20m sprint and multi-stage fitness test) characteristics. To evaluate anthropometric and fitness characteristics by maturity status, players were assigned into annual maturity groups based on their maturity offset (Years from PHV; YPHV) calculated by Mirwald et al. (20). Players that were assessed on consecutive years were investigated for annual change in characteristics to examine longitudinal development of characteristics based on maturity status.

Subjects

A total of 121 male, academy rugby league players (age = 14.40 ± 1.69 years) were used in the study. Data was collected over a five-year period between 2007 and 2011 at the Under 13s, 14s, 15s and 16s chronological annual-age categories. Players could potentially join the academy programme at the Under 13s age category and leave the programme at the Under 16s level (i.e., left the club or progressed to the Under 18s) but throughout this period players were selected to or exited the programme at different stages. This resulted in a mixed cross-sectional and longitudinal dataset whereby players were assessed between one and four times. This data collection provided a total of 206 assessments with change in performance data available on 85 occasions when players were assessed at consecutive age groups (i.e., Under 13s-14s).

Each player was categorised into one of six maturity offset groups (i.e., -2.5 YPHV (-2.99 to -2.0), -1.5 YPHV (-1.99 to -1.0), -0.5 YPHV (-0.99 to 0.0), 0.5 YPHV (0.01 – 1.0), 1.5 YPHV (1.01 to 2.0) and 2.5 YPHV (2.01 – 3.0)). These categories were developed to provide an annual category by maturity status instead of the traditional chronological annual-age grouping. All experimental procedures were approved by the institutional ethics committee with assent and parental consent provided along with permission from the rugby league club.

Procedures

All pre-season testing was completed across two testing sessions in September each year. All testing was undertaken by the lead researcher throughout the five-year period. A standardised warm up including jogging, dynamic movements and stretches was used prior to testing followed by full instruction and demonstrations of the assessments. Anthropometric and fitness assessments were undertaken on all players within the academy, with the procedures for each measure detailed below.

Anthropometry: Height and sitting height were measured to the nearest 0.1 cm using a Seca Alpha stadiometer. Leg length was calculated by subtracting sitting height from standing height. Body mass, wearing only shorts, was measured to the nearest 0.1 kg using calibrated Seca alpha (model 770) scales. Sum of four skinfolds was determined by measuring four skinfold sites (biceps, triceps, subscapular, suprailiac) using calibrated Harpenden skinfold callipers (British Indicators, UK) in accordance with Hawes and Martin (12). Intraclass correlation coefficients (ICC) and typical error measurements (TEM) for reliability of skinfold measurements were $r = 0.954$ ($p < 0.001$) and 3.2%, respectively, indicating acceptable reliability based on established criteria (i.e., >.80; 13).

Maturity: An age at peak height velocity (PHV) prediction equation (20) was used. This involved a gender specific multiple regression equation including chronological age, stature, sitting height, leg length, body mass and their interactions (24) being applied. The equation in boys is Maturity Offset = -9.236 + 0.0002708.Leg Length and Sitting Height interaction – 0.001663.Age and Leg Length interaction + 0.007216.Age and Sitting Height interaction + 0.02292.Weight by Height ratio (20). The prediction equation has a 95% confidence interval for boys of ±1.18 years (20) and relationships with skeletal age have been shown to be strong (i.e., r=0.83; 17). Maturity offset was determined by subtracting age at PHV from chronological age and then allowed individuals to be assigned to a maturity offset group.

Lower-body Power: A countermovement jump with hands positioned on hips was used to assess lower body power via a just jump mat (Probotics, Hunstville, AL, USA). Jump height was measured to the nearest 0.1 cm from the highest of three attempts (14). The ICC and TEM for the vertical jump was $r = 0.903$ ($p < 0.001$) and 2.9%, respectively.

Upper-body Power: A 2 kg medicine ball (Max Grip, China) chest throw power (26). Participants threw the ball horizontally as far as possible while seated with their back against a wall. Distance was measured to the nearest 0.1m from where the ball landed to the wall with the highest of three trials used as the score. The ICC and TEM for the medicine ball chest throw was $r = 0.965$ ($p < 0.001$) and 0.6%, respectively.

Speed: Running speed was assessed over 10 m and 20 m using timing gates (Brower Timing Systems, IR Emit, Draper, UT, USA). Participants were instructed to start in their own time from a standing start 0.5 m behind the initial timing gate. Time was recorded to the nearest 0.01s from the best of three attempts. ICC and TEM of the 10 m and 20 m sprints were $r = 0.812$ ($p < 0.001$), 7.8% and $r = 0.852$, 4.5%, respectively.

Endurance: The multistage fitness test (MSFT; 23) was used to assess endurance performance. Players were required to run 20 m shuttles, keeping to a series of beeps. Running speed increased progressively until the players reached volitional exhaustion. Total distance covered to the nearest 20 m was used to assess endurance performance. The ICC and TEM for the MSFT has been reported as $r = 0.90$ ($p < 0.001$) and 3.1% (6).

Statistical Analyses

All analyses were conducted using SPSS 19.0 with mean and standard deviation (SD) scores calculated for all dependant variables (i.e., anthropometric and fitness characteristics) at each maturity offset group (i.e., -2.5 YPHV). Results are presented cross-sectionally by each maturity group and longitudinally by analysing the change in performance between assessments. MANOVA analyses were used to determine if differences existed between dependant variables and the change in dependant variables between each maturity offset group. A Bonferroni post-hoc analysis was used to determine where any significant differences occurred. Significance levels were set at $p<0.05$ with effect sizes (η^2) also calculated.

RESULTS

Table 1 shows the anthropometric and fitness characteristics of all academy rugby league players according to maturity offset group (i.e., -2.5 YPHV). MANOVA analyses identified significant main effects for maturity offset group ($F_{5, 202} = 15.72$, $p<0.001$, $\eta^2=0.47$, $1-\beta = 1.00$) with a significant large difference found across the groups for all variables with univariate analyses presented in Table 1. Post-hoc analysis found chronological age was significantly greater across the maturity offset groups except between -2.5 and -1.5 and between 1.5 and 2.5 YPHV. Height, sitting height and body mass was also greater in the more mature groups with skinfolds significantly greater in the 1.5 and 2.5 groups compared to the other maturity offset groups.

Sprint speed was greater across the maturity groups, which showed significance between -1.5 YPHV and the four greater maturity offset groups. Vertical jump performance was also greater across the maturity offset groups with significance only demonstrated between the -2.5 and -1.5 and 0.5 and 1.5 YPHV groups. Medicine ball chest throw was significantly greater across the maturity offset groups. For MSFT distance there was no significant difference between any maturational groups with the -2.5 YPHV group actually the covering the greatest distance.

Insert Table 1 near here

Table 2 shows the anthropometric and fitness changes with maturation over time. MANOVA analyses identified a significant main effect for change in performance by maturity offset group ($F_{4, 81}$ = 1.91, p=0.002, η^2=0.20, 1-β = 0.99) demonstrating that change in performance was related to maturity status. Significant differences between maturity offset groups for specific variables were found for height ($F_{4, 81}$ = 13.04, p<0.001, η^2=0.41, 1-β = 1.00) and sitting height ($F_{4,81}$ = 15.72, p=0.009, η^2=0.16, 1-β = 0.98) with the change between the -1.5 to -0.5 and -0.5 to 0.5 YPHV groups significantly greater than the changes that occurred between the 0.5 to 1.5 and 1.5 to 2.5 YPHV groups. No other significant differences in change in performance were identified for any other variable due to the magnitude of variation in the change in anthropometric and fitness characteristics.

Insert Table 2 near here

DISCUSSION

The aims of the present study were to firstly evaluate the anthropometric and fitness characteristics of junior rugby league players by using maturity status to determine annual categories instead of traditional chronological annual-age groups and secondly to longitudinally evaluate the change in performance in relation to maturation during the adolescent period (Under 13s - 16s). Findings identified anthropometric characteristics were greater as maturation increased across the six maturity offset groups with significant differences identified for the change in height and sitting height between the maturity groups with greater growth apparent at around PHV. For fitness characteristics, speed and lower and upper body power developed with maturity status whereas maturity status had no effect on endurance performance. No significant differences were identified for the change in fitness performance across the maturity groups due to the magnitude of variation shown.

Cross-sectional examinations of chronological age, age at PHV and anthropometric characteristics across the maturity offset group's revealed significant interactions. Chronological age was greater and age at PHV was lower as maturity increased. This would be expected as these variables contribute to the YPHV variable used to determine maturity offset within this study and previous research (19,24). Therefore, using YPHV (i.e., maturity offset) as an indicator of maturation includes both the assessment of chronological age and maturation (i.e., age at PHV) providing an alternative to traditional chronological annual-age group classifications. Height, sitting height and body mass were all significantly greater across the maturity offset groups with the more mature players significantly taller and heavier than the less mature players (e.g., Height, -1.5 YPHV = 154.6 ± 6.7, 1.5 YPHV = 176.5 ± 4.7 cm). Findings are expected as these characteristics contribute to the prediction of age at PHV (20), have been demonstrated to be strongly correlated to maturation (e.g., $p<0.001$; 30) and are related to the normal adaptations of growth, maturation and development during adolescence (17). Sum of four skinfolds were significantly greater in the more mature players (e.g., 1.5 YPHV = 38.9 ± 13.2 mm) compared to less mature players (e.g., -1.5 YPHV = 29.0 ± 4.4 mm). During adolescence, fat mass remains reasonably stable (4) with these findings demonstrating that the more mature players selected to the academy possess greater body fat. A possible explanation for this may be that earlier maturing players may have been selected to the academy due to size advantages, in which previous research (28) highlighted increased sum of skinfolds when earlier maturing forwards were compared to later maturing backs. Therefore coaches may select players based on size and maturation, which may be advantageous for forwards positions in rugby due to their game demands (i.e., physical collisions and tackles).

Current findings demonstrated significant differences across maturity offset groups for all fitness characteristics. Generally, fitness performance was greater in the more mature groups for sprint speed (e.g., 20m sprint -2.5 YPHV = 1.98 ± 0.07, 2.5 YPHV = 1.84 ± 0.07 s), vertical jump (e.g., -2.5 YPHV = 35.4 ± 4.2, 2.5 YPHV = 42.8 ± 4.9 cm) and medicine ball throw (e.g., -2.5 YPHV = 3.5 ± 0.4, 2.5 YPHV = 6.3 ± 0.7 m) but not MSFT distance (e.g., -2.5 YPHV = 1872 ± 186, 2.5 YPHV = 1656 ± 251 m). These findings support previous research that maturity is generally related to sprint and explosive performance (i.e., medicine ball throw and vertical jump) during adolescence (18,33), which occurs due to increased testosterone (17), increased muscle volume and size (27) and qualitative changes of the muscle (i.e., contractile properties; 35). However, findings for endurance contradict existing literature (18,33) and may be apparent due to differences in the playing positions (i.e., forwards have lower endurance performance than backs) amongst the maturity offset groups, which is apparent in junior (28) and senior (9) rugby league players. The fact that significant differences were not exclusively identified across all the maturity offset groups (e.g., vertical jump no significant difference between -1.5 YPHV and 2.5 YPHV) support the notion that advanced maturation is not always associated with better performance (28). The increase in sum of four skinfolds (i.e., higher body fat percentage) with increasing maturity offset group may have implications for fitness performance in the current sample due to the negative association between skinfolds and physical performance, previously identified (28). This finding suggests that skinfolds should be monitored regularly during adolescence to assess body fat percentage, with training and nutritional interventions used appropriately to control for excessive skinfolds that could negatively affect fitness performance.

Longitudinal examinations of change in characteristics within adolescent athletes are limited (22), especially considering maturation (31). Current findings demonstrated significant differences in the change in height and sitting height between the less and more mature players as would be expected in relationship to age at PHV. These findings demonstrate that monitoring height during adolescence should be considered in relation to maturational status to understand an individual's potential growth. No significant differences between maturity offset groups were identified for the change in performance for any fitness variable. This is due to the large variability in the magnitude of change between maturity groups (e.g., 20m sprint, -1.5 to -0.5 YPHV = -0.14 ± 0.12 s) demonstrating large individual changes in fitness during adolescence, which may be related to changes in growth and training status. Sprint speed improvements were increased around PHV, which may be related to factors such as increased muscle mass and changes in the muscle-tendon architecture (36). However, current findings contradict reports (22) that sprint performance is reduced leading up to PHV. These longitudinal findings provide comparative data for the expected change in performance in relation to maturity and provide an alternative to previous longitudinal research (6,36), which use chronological annual-age groups. Such data could be applied to estimate potential performance improvements based on current performance levels or used to determine if young athletes are improving at an expected rate.

In conclusion, this study utilised a unique approach to classify anthropometric and fitness characteristics into annual maturity categories, using a maturity offset (i.e., YPHV), instead of traditional chronological annual-age grouping. The comparative data for characteristics generally demonstrates an improvement in both anthropometric and fitness measures in line with maturity, however some characteristics (i.e., MSFT distance) did not follow this path suggesting that advanced maturation does not always result in superior performance. These findings suggest that categorising players by maturity could be an appropriate alternative or additional assessment method for evaluating player performance alongside chronological annual-age categories, especially within adolescent athletes. The longitudinal changes in performance demonstrate significant increases in height around age at

PHV with no further significant differences identified due to the magnitude of variation in performance changes. Longitudinal monitoring should therefore be applied to allow current performance and progress to be tracked to assist in identification, development and coaching practices.

PRACTICAL APPLICATIONS

Due to the limitations of chronological annual-age grouping, considering maturity in the evaluation of performance within adolescent athletes has recently been recommended (15, 34). National governing bodies, coaches, administrators and parents should assess and consider maturation in the assessment and evaluation of youth athletes with YPHV (i.e., maturity offset) a possible alternative or additional method to chronological age for classifying youth athletes. This approach would allow a more detailed assessment of an athlete's current performance level, therefore assisting talent identification and development processes alongside monitoring training adaptations. Measuring player characteristics and performance by maturity offset would allow comparisons to be made in terms of biological development instead of chronological age categories whereby differences in biological maturation can be extensive (e.g., comparison of an early maturing, relatively older individual vs a later maturing, relatively younger player). Likewise, comparing players by maturation may reduce the emphasis placed on physical performance and size during selection, which has resulted in relative age effects and maturational biases within youth rugby league (29) and other sport contexts (e.g., soccer, 18). Lastly, tracking physical characteristics longitudinally over time would assist in selection and development processes to attempt to differentiate between current performance and potential for future development (32).

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Table 1: Anthropometric and fitness characteristics by annual maturity offset group and associated univariate analyses representing group differences

	Maturity Offset Group (YPHV)						MANOVA		
	-2.5 (n=6)	**-1.5 (n=19)**	**-0.5 (n=30)**	**0.5 (n=55)**	**1.5 (n=67)**	**2.5 (n=29)**	**F**	**P**	η^2
Age (years)	12.48 ± 0.38	13.30 ± 0.68	13.92 ± 0.86[a,b]	14.61 ± 0.71[a,b,c]	15.22 ± 0.58[a,b,c,d]	15.63 ± 0.44[a,b,c,d]	57.05	<0.001	0.59
Age at PHV (years)	14.72 ± 0.43	14.55 ± 0.72	14.23 ± 0.81	13.99 ± 0.62[b]	13.76 ± 0.49[a,b,c]	13.38 ± 0.39[a,b,c,d]	13.69	<0.001	0.26
Height (cm)	147.1 ± 5.2	154.6 ± 6.7	164.7 ± 6.0[a,b]	171.8 ± 4.6[a,b,c]	176.5 ± 4.7[a,b,c,d]	180.5 ± 5.5[a,b,c,d]	102.07	<0.001	0.72
Sitting Height (cm)	72.7 ± 3.2	76.8 ± 3.5[a]	82.3 ± 3.5[a,b]	86.4 ± 2.6[a,b,c]	89.8 ± 2.2[a,b,c,d]	92.7 ± 2.5[a,b,c,d,e]	139.06	<0.001	0.78
Body Mass (kg)	37.9 ± 2.5	45.9 ± 4.7	54.7 ± 6.4[a,b]	65.8 ± 6.2[a,b,c]	74.3 ± 8.1[a,b,c,d]	83.2 ± 10.0[a,b,c,d,e]	107.35	<0.001	0.73
Skinfolds (mm)	24.8 ± 3.8	29.0 ± 4.4	27.6 ± 4.6	31.9 ± 8.6	38.9 ± 13.2[a,b,c,d]	47.1 ± 16.6[a,b,c,d,e]	14.24	<0.001	0.26
10m Sprint (s)	1.98 ± 0.07	1.96 ± 0.06	1.89 ± 0.09[b]	1.87 ± 0.10[b]	1.84 ± 0.08[a,b]	1.84 ± 0.07[a,b]	9.25	<0.001	0.19
20m Sprint (s)	3.46 ± 0.08	3.44 ± 0.11	3.28 ± 0.15[b]	3.22 ± 0.17[a,b]	3.17 ± 0.13 [a,b,c]	3.15 ± 0.11[a,b,c]	16.92	<0.001	0.30
Vertical Jump (cm)	35.4 ± 4.2	39.1 ± 4.2	41.1 ± 5.8	43.6 ± 5.2[a,b]	43.4 ± 6.4[a,b]	42.8 ± 4.9	4.26	0.001	0.10
Medicine Ball Throw (m)	3.5 ± 0.4	4.0 ± 0.5	4.8 ± 0.7 [a,b]	5.6 ± 0.6 [a,b,c]	6.0 ± 0.6 [a,b,c,d]	6.3 ± 0.7[a,b,c,d]	69.20	<0.001	0.64
MSFT Distance (m)	1872 ± 186	1547 ± 267	1637 ± 223	1670 ± 303	1675 ± 275	1656 ± 251	2.27	0.044	0.05

[a]Significantly different to -2.5 (P<0.05); [b]Significantly different to -1.5 (P<0.05); [c]Significantly different to -0.5 (P<0.05); [d]Significantly different to 0.5 (P<0.05); [e]Significantly different to 1.5 (P<0.05).

Table 2: Change in anthropometric and fitness characteristics between annual maturity offset groups

	Change between maturity offset groups (YPHV)				
	-2.5 to -1.5 (n=6)	**-1.5 to -0.5 (n=13)**	**-0.5 to 0.5 (n=19)**	**0.5 to 1.5 (n=30)**	**1.5 to 2.5 (n=17)**
Height (cm)	5.4 ± 2.9	7.3 ± 2.1	6.1 ± 2.3	3.4 ± 2.0[a,b]	2.0 ± 0.8[a,b]
Sitting Height (cm)	2.5 ± 1.6	4.0 ± 2.5	3.7 ± 2.0	3.0 ± 2.1	1.6 ± 1.0[a,b]
Body Mass (kg)	5.8 ± 2.0	8.5 ± 2.2	9.4 ± 3.4	6.7 ± 3.5	5.7 ± 5.8
Skinfolds (mm)	2.5 ± 3.6	-1.0 ± 3.0	1.8 ± 3.3	2.4 ± 6.0	-2.2 ± 9.0
10m Sprint (s)	-0.03 ± 0.03	-0.07 ± 0.07	-0.05 ± 0.09	-0.06 ± 0.08	-0.03 ± 0.04
20m Sprint (s)	-0.04 ± 0.02	-0.14 ± 0.12	-0.13 ± 0.12	-0.10 ± 0.10	-0.07 ± 0.06
Vertical Jump (cm)	4.1 ± 3.0	3.0 ± 4.4	3.7 ± 4.1	2.8 ± 4.1	2.1 ± 3.1
Medicine Ball Throw (m)	0.55 ± 0.37	0.64 ± 0.35	0.81 ± 0.38	0.63 ± 0.45	0.53 ± 0.30
MSFT Distance (m)	15 ± 64	142 ± 192	111 ± 206	83 ± 250	35 ± 226

[a]Significantly different to -1.5 to -0.5 YPHV (*P*<0.01); [b]Significantly different to -0.5 to 0.5 YPHV (*P*<0.01)

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