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Original research

Motor Competence and Body Composition in young adults: An exploratory study

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ABSTRACT

Background: The association between obesity and physical inactivity strongly and independently predict overall obesity in young adulthood. Physical inactivity and increasing obesity in our society is multifaceted, but on key factor to promote physical activity is motor competence (MC).

Purpose: This study aimed to analyse a physically active group of young adults by investigating the correlations between MC, adiposity and body mineral density by using dual X-ray absorptiometry (DXA).

Methods: Forty-four young men (22,1 ± years; 69,0 ± kg; 173,7 ± meters) and 21 young women (20,2 ± years; 63,8 ± kg; 169,6 ± meters) participated in this study and completed anthropometrics; DXA; Motor Competence assessment battery that comprise two tests for each of the three constructs: locomotor, manipulative and stability. Descriptive statistics were considered and Spearman's correlation test to examine the association between MC scores and DXA results. The Mann-Whitney test was used to compare males to females for $p < 0,05$.

Results: Motor Competence (MC) variables and body composition in female revealed significant associations only between shuttle run and total fat ($r = -0,648$). In males, demonstrate several positive statistically associations with MC Stability and Locomotor tasks and constructs ($p < 0,05$).

Conclusions: In very active young adults, MC positive influences weight status, particularly in locomotor and stability tasks.

1. Introduction

Over weightness and obesity are public health problems due to their association with morbidity and mortality (Bjorntorp et al., 2000; Gaio et al., 2018). The prevalence of overweightness and obesity in most European countries is increasing and is one of the most common health problems in Portugal (Gaio et al., 2018). Physical inactivity is a major problem, and has become a global pandemic (Sallis et al., 2016). Eliminating physical inactivity could lead to a 0.68 years increase in life expectancy of the world's population (Lee et al., 2012) with significant economic impacts, since physical inactivity is also a major economic burden worldwide (Ding et al., 2016).

The association between obesity and physical inactivity strongly and independently predict overall (and especially abdominal) obesity in young adulthood (Hills et al., 2011; Pietiläinen et al., 2008). Obesity and physical inactivity operate in a self-perpetuating vicious circle, as a physically inactive lifestyle fosters weight gain and vice versa, independent of genetic effects (Pietiläinen et al., 2008). Physically inactive adolescents demonstrate a significantly increased risk of obesity during adulthood, as the transition period from adolescence to young adulthood is a crucial time that determines one's lifestyle (Pietiläinen et al., 2008).

The problem of physical inactivity and increasing obesity in our society is multifaceted, but one key factor that promotes physical activity is motor competence (MC) (Stodden et al., 2008). This observation is linked to the fact that the development of MC is a vital underlying mechanism that promotes engagement in physical activity; it is both a precursor and a consequence of one's weight status (Robinson et al., 2015; Stodden et al., 2008). MC demonstrates an inverse relationship with weight status across childhood and adolescence

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(Robinson et al., 2015). Longitudinal studies establish that MC is a strong predictor for physical activity (Lopes et al., 2012a) and physical fitness (Rodrigues et al., 2016). Longitudinal studies demonstrate that lower MC in children is associated with increased body mass index (Lopes et al., 2012a) and with weight status (Lubans et al., 2010). The strength of association over time demonstrate a negative developmental trajectories between MC and body fat across childhood and into adolescence since those with lower MC performance at baseline had higher risk of having higher fat levels after 7 years (Lima et al., 2018). This associations emerge at pre-school age and become stronger during elementary school years, being less conclusive beyond this age (Robinson et al., 2015).

To the best of our knowledge, there are few studies that test body composition, physical activity and MC in the transition from adolescence to young adulthood. Based on the importance of such factors in controlling the global problem of overweightness, this study aimed to analyse a physically active group of young adults by investigating the correlations between MC, adiposity, and body mineral density by using dual X-ray absorptiometry.

2. Material and methods

2.1. Participants

Forty-four young men (22,1 ± years; 69,0 ± kg; 173,7 ± meters) and 21 young women (20,2 ± years; 63,8 ± kg; 169,6 ± meters), who were students in a Faculty of Sports Sciences undergraduate course volunteered to participate in the present study. All participants had no motor, cognitive, or health impairments that could affect their performance. Participants were informed of the study design, as well as of the potential risks and benefits of participating. The study was approved by the school's board and scientific council (CTC-ESDL-CE002-2017). All participants signed a free informed consent in accordance with the ethical standards of the study in humans as suggested by the Declaration of Helsinki.

2.2. Procedures

All participants had their MC assessed and their anthropometrics measures taken. The data were collected during the first month of the academic year (from October to November). Firstly, to characterize physical activity profile, all subjects fulfilled the habitual physical activity questionnaire (Baecke et al., 1982) validated for the Portuguese population (Almeida and Ribeiro, 2014) and gave their informed consent. The assessments were made during the morning period in an indoor facility at an average temperature of 26 °C and a relative humidity of 18%. The tests were conducted in the following sequence: 1) anthropometric; 2) dual X-ray absorptiometry; 3) MC.

The Portuguese version of Becke's habitual physical activity questionnaire (Almeida and Ribeiro, 2014) determines one's habitual physical activity scores over the past 12 months. The questionnaire includes eight items grouped into two dimensions: 1) Physical Activity – Sports (four items), which evaluates the physical activity performed in the sport or programmed physical exercise practiced during leisure hours and 2) Physical Activity – Leisure (four items), which evaluates physical activity in activities other than sports, practiced during leisure time (e.g., walking, cycling). If an individual answered the questions in the first dimension in the negative, that individual was excluded from the analyses.

2.3. Body composition

The body weights of all subjects were assessed on a scale (SECA 760, Germany), and their heights were measured by a portable stadiometer (SECA 217, Germany). During the evaluations, the participants dressed in light clothing and stood barefoot. Weight measurements were rounded to the nearest 0,5 kg and their height measurements to the nearest 0,1 cm, with the head oriented according to the Frankfurt plane. Body mass index (BMI) was calculated and recorded in kg/m^2, and body composition was analysed according to dual-energy X-ray absorptiometry (DXA), with a General Electric Hologic Discovery scanner (Hologic Inc., Waltham, MA, USA). A certified and experimented DXA operator performed all evaluations according to the manufacturer's specifications while assisting the participant to 1) straighten their head, neck, and torso to be parallel to the long axis of the scan bed; 2) position their shoulders and pelvis perpendicular to the long axis of the scan bed; 3) place both arms in pronation by their side; 4) place their legs shoulder -width apart with an internal rotation of 45°; and 5) fixate their feet together using strapping tape to minimize incidental movement and for the participants' comfort (Hart et al., 2015).

DXA provides information on three compartments of body composition: fat mass, lean mass or fat-free soft tissue, and bone mineral content. Only the data for fat mass and bone mineral density (BMD) were included in the analyses.

2.4. Motor competence assessment

The MC assessment (MCA) (Luz et al., 2016) battery was applied to evaluate MC. The MCA is composed of two tests for three categories: locomotor (shuttle run and standing long jump), manipulative (throwing and kicking ball velocity), and stability (lateral jumps and shifting platforms).

2.4.1. Shuttle run (SHR)

Participants were required to run a distance of 4 × 10 m, running at their maximal speed between the start and finish line. The test began at the starting line after an acoustic starting sound. Then, participants ran to the opposite line, picked up a block of wood, ran back and placed the block beyond the starting line. Without stopping, subjects ran back to retrieve a second block and to carry it back across the starting line to finish the test. The best time of the two trials was recorded.

2.4.2. Standing long jump (SLJ)

Participants were required to jump with both feet at the same time as far as possible. The test began with both feet placed on the starting line. After three attempts, the longest distance between the starting line and the back of the heel at landing was scored in centimeters.

2.4.3. Throwing velocity (TV)

Participants were required to throw a baseball (diameter: 7,3 cm; weight: 142 g) against a wall at their maximum speed using an overarm action with a preparatory balance.

2.4.4. Kicking velocity (KV)

Participants were required to kick a soccer ball n°5 (circumference: 68 cm; weight: 410 g) against a wall at their maximum speed using a preparatory balance. For the TV and KV tests, peak velocity was measured in m/s with a Stalker ATS II Radar System (Applied Concepts, Inc., TX, USA). The radar gun was placed on a tripod and positioned behind a target marked on the wall in front of the kicking and throwing line. Each subject performed three trials, with the final score being the best result.

2.4.5. Lateral jumps (LJ)

Participants were required to jump sideways as fast as possible for 15 s. During testing, participants jumped, with their feet together, over a small wooden beam (60 cm length × 4 cm high × 2 cm width) located in the middle of a rectangular surface (100 cm length × 60 cm width). Each correct jump (i.e., a jump made without touching the outside the rectangle or the wooden beam) was awarded one point, and the best score was recorded the best score was recorded after two trials.

2.4.6. Shifting platforms (SP)

Participants were required to move sideways using two wooden platforms (25 cm × 25 cm × 2 cm, with four 3,7 cm) with their feet at the corners for 20 s. Each successful transfer from one platform to the other was scored. One point was achieved for moving the platform, and another point was awarded for moving into the platform (i.e., each complete successful transfer resulted in two points). Participants completed two trials, and the best score was recorded.

To obtain scores for each MC category (stability, locomotor, and manipulative), the sum of the t-scores of the two tasks was calculated. Inverse t-values were used for SHR, given that higher values represented lower performance, and total MC was calculated as the mean of the t-scores for all categories. (Luz et al., 2016; Luz et al., 2017).

2.5. Statistical analyses

Descriptive statistics (averages and 95% confidence intervals for lower and upper limits) were calculated. Spearman's correlation test was performed to examine the association between MCA scores and DXA results. The following correlation scale was adopted (Hopkins et al., 1996): trivial ($r < 0{,}1$); small ($0{,}1 \le r < 0{,}3$); moderate ($0{,}3 \le r < 0{,}5$); large ($0{,}5 \le r < 0{,}7$); very large ($0{,}7 \le r < 0{,}9$); and nearly perfect ($\ge 0{,}9$). The Mann-Whitney test was used to compare males to females. The effect size (ES) to non-parametric tests is obtained (Pallant, 2011): $r = \frac{|z|}{\sqrt{N}}$, where N is the total sample size, and the value of z is reported after applying the Mann-Whitney test. The classification of ES is obtained by using the following criteria (Pallant, 2011): very small effect ($r < 0{,}1$); small effect ($0{,}1 \le r < 0{,}3$); medium effect ($0{,}3 \le r < 0{,}5$); and large effect ($r \ge 0{,}5$).

All statistical analyses were completed using SPSS version 22.0.0.0 for Windows (IBM, USA) for $p < 0{,}05$.

3. Results

According to the results of the habitual physical activity questionnaire, eight males and four females were excluded from the analyses. Tables 1 and 2 present sample descriptions and comparisons between males and females.

The comparison between males and females revealed that males had a significantly lower total percentage of fat (p = 0,000; ES = 0,579; large ES), trunk percentage of fat (p = 0,001; ES = 0,454; medium ES) and higher BMD (p = 0,009; ES = 0,360; medium ES). This comparation but in MC, demonstrate that male have better statistically significant results in all items (Table 2).

The correlations between MC variables and body composition in females (Table 3), presents only a significant association between shuttle run and total fat (r = 0,583 [95%CI: 0,142; 0,831]; p = 0,036; positive and large).

The same analyses for males (Table 4) demonstrates negative significant associations between shifting platforms and total percentage of fat mass (r = −0,507 [95%CI: −0,716; −0,214]; p = 0,011; negative and large); standing long jump and total percentage of fat mass (r = −0,582 [95%CI: −0,764; −0,313]; p = 0,002; negative and large); shifting platforms and trunk percentage of fat mass (r = −0,526 [95%CI: −0,729; −0,239]; p = 0,008; negative and large); standing long jump and trunk percentage of fat mass (r = −0,533 [95%CI: −0,733; −0,248]; p = 0,005; negative and large); shifting platforms and total fat mass (r = −0,481 [95%CI: −0,699; −0,181]; p = 0,018; negative and moderate); standing long jump and total fat mass (r = −0,535 [95%CI: −0,734; −0,250]; p = 0,005; negative and large). Positive significant associations were found between Shuttle Run and Total percentage of fat mass (r = 0,478 [95%CI: 0,697; 0,177]; p = 0,018; positive and moderate); Shuttle Run and trunk percentage of fat mass (r = 0,443 [95%CI: 0,674; 0,134]; p = 0,030; positive and moderate); Shuttle Run and total fat mass (r = 0,500 [95%CI: 0,712; 0,205]; p = 0,013; positive and large); bone mineral density and throwing velocity (r = 0,495 [95%CI: 0,708; 0,199]; p = 0,019; positive and moderate);

Analysing the data, concerning the MC constructs revealed a positive association with MC manipulative and bone mineral density (r = 0,469 [95%CI: 0,691; 0,166]; p = 0,028; positive and moderate). The remaining associations were significant and negative, regarding stability and locomotor variables: MC stability and total percentage of fat mass (r = −0,507 [95%CI: −0,716; −0,214]; p = 0,011; negative and large); MC stability and trunk percentage of fat mass (r = −0,554 [95%CI: −0,747; −0,276]; p = 0,005; negative and large); MC stability and total fat mass (r = −0,481 [95%CI: −0,699; −0,181]; p = 0,018; negative and moderate); MC locomotor and total percentage of fat mass (r = −0,582 [95%CI: −0,669; −0,125]; p = 0,024; negative and large);

Table 1
Sample description (mean and 95%CI).

	Male (n = 36)	Female (n = 17)
Age (years old)	22,2 [19,5–24,8]	20,4 [19,2–21,6]
Height (cm)	174,0 [171,3–176,7]	169,3 [163,7–174,8]
Weight (kg)	69,4 [65,5–73,4]	63,5 [58,0–68,9]
Total fat mass (%)	20,9 [18,9–22,8]*	29,9 [27,1–32,8]
Body Mass Index (kg/m^2)	23,6 [22,7–24,5]	22,2 [20,8–23,6]
Trunk fat mass (%)	19,8 [17,6–22,0]*	26,3 [23,1–29,5]
Total fat mass (g)	3900,4 [3171,4–4629,5]	4579,0 [3858,7–5299,3]
BMD (g/cm^2)	1,3 [1,2–1,3]*	1,2 [1,1–1,2]

cm – centimetres; kg – kilograms; % - percent; BMD - Bone mineral density; g/cm^2 - grams per square centimetre; g - grams; kg/m^2.- kilogram per square meter; * significant differences comparing males and female, p < 0,05.

4. Discussion

In physically active young male adults, MC locomotor and stability tasks are negatively influenced by fat mass (Table 4). This correlations are similar to those found in previous research, that, when compared to normal-weight children and adolescents, overweight children and adolescents had more difficulty performing antigravity activities like running or jumping (Okely et al., 2004; Prskalo et al., 2015). In fact, the morphological constraint hypothesis (Niederer et al., 2012) posits that being too heavy does not help one perform activities that involve changes in their centre of mass, like locomotor activities. Interestingly, the sample for the present study was composed of active young adults from a sports science undergraduate course (Table 1), whose behavioural attributes, skills category, physical activity and sports participation are correlated to MC (Barnett et al., 2016).

The observed statistically significant differences found between sexes, Table 1 (i.e., a lower total percentage of fat, a lower trunk percentage of fat, and a higher BMD for males) are well-established in several studies. (Karastergiou et al., 2012). These data also agree with previous research in that sex differences in MC (Table 2) exist (Lopes et al., 2012b; Luz et al., 2019, 2017) and are also well established in active young adults.

The female group only presented a statistically significant association between shuttle run and total fat (r = 0,583; p = 0,036). As specified earlier, the positive correlation between shuttle run and total fat is expected since weight status is known to influence antigravity activities (Okely et al., 2004; Prskalo et al., 2015). Although, the 10 m shuttle run assesses speed and/or agility, presenting variability between sexes and an inverse relationship with adiposity (Ortega et al., 2008).

In divergence, the male group, present several significant associations. The positive associations are between Bone Mineral Density (BMD) and MC manipulative (r = 0,469; p = 0,028), BMD and throwing velocity (r = 0,495; p = 0,019), and Shuttle Run and all fat mass measurements (Table 4). Men exhibit higher BMD throughout life and during growth, with peak bone mass occurring between the

Table 2
Motor Competence description (mean and 95%CI).

	Male (n = 36)	Female (n = 17)	p value	Effect Size
Motor Competence Stability	102,3 [95,65–109,1]*	89,1 [83,2–95,3]	0,010	small effect (0,290)
Shifting Platforms (nº rep)	31,8 [30,2–33,3]*	29,4 [28,3–30,4]	0,003	medium effect (0,332)
Lateral Jumps (nº rep)	51,2 [48,1–54,3]*	46,1 [43,1–49,0]	0,043	small effect (0,226)
Motor Competence Manipulative	109,7 [105,5–113,8]*	75,6 [67,9–83,3]	0,000	large effect (0,591)
Throwing velocity (m/s)	22,1 [21,1–23,1]*	15,2 [13,5–16,9]	0,000	large effect (0,543)
Kicking velocity (m/s)	25,2 [24,2–26,2]*	18,2 [16,4–19,9]	0,000	large effect (0,572)
Motor Competence Locomotor	99,5 [93,8–105,2]*	97,6 [95,6–99,7]	0,021	small effect (0,258)
Standing Long Jump (cm)	222,1 [213,7–230,6]*	182,3 [168,8–195,7]	0,000	large effect (0,635)
Shuttle Run (s)	9,4 [8,7–10,1]*	10,9 [10,6–11,3]	0,000	large effect (0,549)

nº rep. number of repetitions; m/s – meters per seconds; cm – centimetres; s – seconds; ∗ significant differences comparing males and female, $p < 0,05$.

twenties and thirties (Santos et al., 2017). Therefore, the positive association, was expected, since this sample is in the age range and lower BMD has been observed in adolescents with motor difficulties (Hands et al., 2019) and in children, adolescents, and adults with low motor competence (Cantell, Crawford, & (Tish) Doyle-Baker, 2008). Even though, greater motor competence at 18 months was found to be associated with higher hip BMD and predicted bone strength at 17 years, particularly in males (Ireland et al., 2016). The other positive association between Shuttle Run and all dimensions of fat mass are in line with the reported for the female group. Although, this association have more strength than other studies (Slotte et al., 2018) since is used a direct measure of body fat (DXA). As expected, the remaining statistically associations, are negative. Children's with low MC, present higher body mass index (Cantell et al., 2008; Lopes et al., 2012b). Body Mass Index (BMI) related differences appeared to become more pronounced as children belonged to an older age group (D'Hondt et al., 2011). Additionally, it is expected that the highest MC group will show lower results on BMI, independently of age and gender, in comparison to the lowest MC group (Fransen et al., 2014; Lopes et al., 2012b; Rodrigues et al., 2016). However, this expected associations are not verified in this physical active young adult. These outcomes may be mediated by the fact that BMI is an indirect measure of body fat and less sensible in active individuals (Nuttall, 2015). Actually, a recent systematic review (Slotte et al., 2018) that analyse the relation between fundamental motor skills and weight status, indicate that 42% of the studies that use BMI, as measure of weight status, do not found any statistically significant associations.

MC locomotor and stability constructs, comprise shuttle run, standing long jump, shifting platforms, and lateral jumps. As anticipated, most of the associations, presents significant and negative associations with fat mass (Table 4). These results are in line with several cross-sectional and longitudinal studies that found an inverse association between MC and different assessments for body composition (skinfolds, waist circumference or BMI) (D'Hondt et al., 2011; Greier and Drenowatz, 2018; Henrique et al., 2016; Rodrigues et al., 2016) and DXA (Slotte et al., 2015). Children with more rapid increase in motor competence along childhood are less prone to develop an overweight or obesity condition (Rodrigues et al., 2016). The fact that in this study all subjects are very physical active, may have some "protector effect", since was demonstrated that weight status level at the beginning of primary school (first assessment) showed a significant effect on weight status risk, meaning that a one point increase in BMI at baseline was associated with doubling of the odds of being overweight or obesity at the end of primary school (second assessment) (Rodrigues et al., 2016). Nevertheless, our data have more strength because cover the need for studies where body composition is accurately measured (DXA) and motor skills assessed with standardized and global method. (Slotte et al., 2018).

The less correlation found when compared female with male may be mediated by the fact that, even being all physical active, female tend to be less physical active than male (Thompson et al., 2003) and the assessment was made with product-oriented instrument that tend to be more influenced by biological factor that process-oriented (qualitative) instruments (Hardy et al., 2012).

Because the development of MC is not a factor in the age group analysed in the present study, the positive spiral of physical activity engagement through MC that ultimately impacts one's weight status isn't so evident; still; MC correlates to weight status, especially in male, on locomotor and stability tasks.

Besides the limitation concerning sample size and the distribution between the groups, the cross-sectional design, makes impossible to generalise the results. The associations among MC and body composition need more research, particularly using a large sample of predominantly active young adults who have normal weights. This study is exploratory, and the assessment using a quantitative instrument in this age group is at the same time a strength and a limitation because of the impossibility to compare the results with other similar methodology.

5. Conclusion

Fat mass is important factor in locomotor and manipulative MC constructs. Locomotor and stability tasks are negatively correlated with

Table 3
Motor Competence and Body Composition correlations from female that *assume to perform regular Physical Activity (correlation and 95%CI).*

	Total % FAT	Trunk % FAT	Total FAT (g)	BMD (g/cm^2)	BMI (kg/m^2;)
Motor Competence Stability	−0,352	−0,357	−0,207	0304	−0,316
Shifting Platforms	−0,395	−0,427	−0,334	0216	−0,458
Lateral Jumps	−0,192	−0,122	0021	0,073	0134
Motor Competence Manipulative	−0,095	0033	−0,090	−0,042	0086
Throwing velocity	−0,165	−0,033	−0,055	−0,279	0086
Kicking velocity	−0,020	0156	0,064	0090	0,136
Motor Competence Locomotor	−0,291	−0,069	0071	0,192	−0,022
Standing Long Jump	−0,629 P = 0,016	−0,423	−0,455	0326	−0,258
Shuttle Run	0,525	0388	0,583* [0,142; 0,831]	−0,193	0127

Motor Competence and Body Composition correlations from female that assume to perform regular Physical Activity (correlation and 95%CI); % – Percentage; FAT – fat mass; BMD - Bone mineral density; g/cm2 – grams per square centimetre; BMI - Body Mass Index; kg/m^2 - kilogram per square metre; *$p < 0,05$.

Table 4

Motor Competence and Body Composition correlations from male that *assume to perform regular Physical Activity (correlation and 95%CI).*

	Total % FAT	Trunk % FAT	Total FAT (g)	BMD (g/cm^2)	BMI (kg/m^2)
Motor Competence Stability	−0,507* [−0,716; −0,214]	−0,554* [−0,747; −0,276]	−0,481* [−0,699; −0,181]	−0,008	−0,103
Shifting Platforms	−0,519* [−0,724; −0,230]	−0,526* [−0,729; −0,239]	−0,547* [−0,742; −0,266]	0,087	−0,245
Lateral Jumps	−0,335	−0,356	−0,22	−0,004	0209
Motor Competence Manipulative	−0,100	−0,170	−0,047	0,495* [0,708; 0,199]	0,079
Throwing velocity	0,144	−0,170	0,1678	0,469* [0,691; 0,166]	0,280
Kicking velocity	−0,245	−0,305	−0,174	0331	−0,039
Motor Competence Locomotor	−0,436* [−0,669; −0,125]	−0,335	−0,400	−0,382	−0,116
Standing Long Jump	−0,582* [−0,764; −0,313]	−0,533* [−0,733; −0,248]	−0,535* [−0,734; −0,250]	−0,072	−0,244
Shuttle Run	0,478* [0,697; 0,177]	0,443* [0,674; 0,134]	0,500* [0,712; 0,205]	−0,226	0179

Motor Competence and Body Composition correlations from male that assume to perform regular Physical Activity (correlation and 95%CI); % – Percentage; FAT – fat mass; BMD - Bone mineral density; g/cm^2 – grams per square centimetre; BMI - Body Mass Index; kg/m^2 - kilogram per square metre; *p < 0,05.

fat mass and manipulative tasks with bone mineral density, in young male adults.

In very active young adults, MC positive influence weight status, particularly in locomotor and stability tasks.

Conflicts of interest

Authors state no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.obmed.2019.100087.

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