Association between Body Mass Index and Cognitive Performance in Rugby Players

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Abstract- Poor cardiovascular fitness has been implicated as a possible mechanism for obesity-related cognitive decline, though no study has examined whether BMI is associated with poorer cognitive function in persons with excellent fitness levels. The aim of this study is to investigate the relationship between body mass index and cognitive performance in rugby players. Thus, fifteen rugby players male aged 24.7 ± 0.9 voluntarily participated in this study, whose body mass index (BMI) was greater than 30. The intercorrelations matrix between BMI and the five ImPACT composite scores showed that BMI is negatively correlated with verbal memory (r = -0.181; p<0.01), visual memory (r = -0.172; p<0.01) and visual motor speed (r = -0.103; p<0.05). Also, the results showed that there was no significant correlation between BMI and reaction time or between BMI and impulse control. The findings of the current study indicate that BMI is negatively associated with cognitive function in a sample expected to have better than average cardiovascular fitness. BMI was found to be associated with reduced cognitive performance in rugby players, but only in specific areas of functioning. Notably, measures of memory had the greatest associations with BMI while no association was found on measures related to executive function and attention.

Index Terms- Body mass index, cognitive performance, rugby players

I. INTRODUCTION

Overweight and obesity are a major public health issue. Despite increased awareness, the prevalence of obesity continues to rise in many countries. In 2008, an estimated 1.5 billion people worldwide were overweight (BMI ≥ 25–29.9 kg/m²), with 500 million considered obese (BMI ≥ 30 kg/m²) [1].

Overweight and obese individuals are at elevated risk for numerous health problems, including cardiovascular disease, type 2 diabetes, musculoskeletal disorders, and even some forms of cancer [1, 2].

There is growing evidence that obesity is also associated with adverse neurocognitive outcomes including Alzheimer’s disease [3], stroke, and vascular dementia [4]. Research also demonstrates an association between obesity and impaired cognitive functioning long prior to the onset of these conditions. Even after controlling for comorbid medical conditions, obese individuals exhibit deficits in multiple cognitive domains, including attention, executive function, and memory [5, 6].

The mechanisms for obesity-related cognitive dysfunction remain poorly understood. Neuroimaging studies link obesity to structural and functional changes, including greater atrophy, development of white matter hyperintensities [7], reduced neural connectivity [8], and decreased blood flow in frontal brain regions [9]. Other work demonstrates aspects of glycemic controls, including altered insulin sensitivity and insulin resistance, as important contributors to obesity-related cognitive dysfunction [10, 11].

Another likely contributor to obesity-related cognitive dysfunction is reduced cardiovascular fitness. Many obese individuals have poor cardiovascular fitness, perhaps attributable to low levels of physical activity found in this population [12, 13]. In turn, low levels of cardiovascular fitness are associated with reduced cognitive function in a variety of healthy and patient samples [14, 15], and improvements in cardiovascular fitness correspond to improved neuropsychological test performance [8, 14, 16, 17]. Similarly, a weight loss program combining diet and exercise was associated with improved neurocognitive functioning in obese adults [18].

The regular practice of physical activity is now recognized as an important element of good physical and mental health and this for all ages. The effect of physical activity on the brain, particularly on cognitive function is a recent approach. The most obvious benefits are observed in the elderly in whom physical activity helps people to slow cognitive decline associated with aging [19, 20, 21].

Childhood is a critical period in the development of certain cognitive functions [22, 23] and young people are confronted daily with learning situations. Thus, determining the effects of physical activity on cognitive functioning in children appears an important public health issue. However, a deterioration of the physical condition of young observed in recent decades [24]. Thus, further knowledge about the relationship between physical activity, cognitive functioning and physiological mechanisms underlying this relationship could guide the development of public health policy and education.

The effects of physical activity induce a transient modification of the cognitive performance in children and adolescents [25].

This is the case of Pesce et al. [26] who examined the short-term memory and long term memory in students of 11 and 12 years who participated in either circuit training or a team sport. The two types of physical exercise were similar intensity and duration, that is to say approximately 40 minutes at an average of about 140 bpm FC. This research reveals that team sport has...
been beneficial to both types of memory while circuit training has only been beneficial to the long-term memory. Budde et al. [27] found a race of 12 minutes at an average intensity (between 50 and 65% of maximum heart rate) was beneficial for adolescents who initially showed a low capacity of working memory. The execution of same exercise at a higher intensity (between 70 and 80% of maximum heart rate) was not effective. Some recent studies have examined executive functions in schools have also been documented. First, Kubesch et al. [28] examined the effect of physical exercise two conditions on the performance of an inhibition test in older adolescents between 13 and 14 years. The results suggest that physical education classes of 30 minutes are beneficial for executive functions, but not a short session of aerobic exercise class in five minutes. Furthermore, Hill et al. [29, 30] have shown that 10-15 minutes of moderate-intensity aerobic exercises were beneficial to executive functions in children aged between 8 and 12 years, even if the cognitive tests were completed nearly an hour after cessation of exercise. However, it should be noted that the benefits were only observed in children who had previously been exposed to the tests used.

Physical exercise does not seem to systematically induce positive effects on cognitive functioning. Thus, some research suggests differential effects depending on the age of the participants [31], nature [32, 26] and the amount of exercise [33, 34, 27, 28].

However, obesity is defined as overweight with excess body fat has adverse consequences for health. The measurement of body fat is difficult to achieve in clinical practice, estimates of overweight is used to define obesity: body mass index (BMI), which is equal to the weight (in kilograms) divided by height (in meters) squared. According to the classification adopted by the World Health Organization [35]: underweight is defined as a BMI less than or equal to 18.5 ; normal is defined by a BMI greater than or equal to 18.5 but less than or equal to 24.9 ; overweight is defined as BMI greater than or equal to 25 but less than or equal to 29.9 ; obesity is defined as a BMI greater than or equal to 30.5.

Obesity itself is divided into three classes: class I or moderate obesity (30 ≤ BMI ≤ 34.9); class II or severe obesity (35 ≤ BMI ≤ 39.9); class III or morbid obesity (BMI ≥ 40). In children and adolescents (<18 years) [36, 37], underweight is defined as BMI <3rd percentile; the normal weight is defined by the 3rd ≤ BMI <97th; overweight is defined as BMI ≥ 97th and obesity is defined by a threshold ≥ IOTF-30 [38].

Despite these findings, the contribution of physical fitness to obesity-related cognitive function remains unclear as risk factors often come into play. For example, rugby players often have cardiovascular risk factors and type 2 diabetes [38], despite excellent fitness levels. No study to date has examined the association between body composition and cognitive function in a sample of persons expected to have better than average fitness levels. To do so, we examined BMI and cognitive function in a sample of rugby players.

Based on the independent effect of obesity on cognition in past work, we expected that higher BMI would be associated with poorer cognitive function. Thus the aim of this study is to investigate the relationship between body mass index and cognitive performance in rugby players

II. METHODS

2.1. Subjects

Fifteen rugby players male aged from 21 to 26 years voluntarily participated in this study, whose body mass index (BMI) was greater than 30.

None of the subjects were using drugs or other therapy for obesity, and none had prior histories of disease or injury that would prevent daily exercise.

All of these players selected at random and did not receive at any time a special diet instruction. Before enrolling in the study, subjects were informed of the experimental procedures, as well as the potential risks and benefits associated with the study. However, they were not informed of the study’s purpose. To be included in the study, each subject provided written consent in accordance with the Declaration of Helsinki.

<table>
<thead>
<tr>
<th>Table 1: Characteristics of study subjects.</th>
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<tbody>
<tr>
<td>Age (Years)</td>
</tr>
<tr>
<td>Body mass (kg)</td>
</tr>
<tr>
<td>Height (m)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
</tr>
</tbody>
</table>

2.2. Procedures

Subjects were asked to be alone and away from any other person so that there is no communication during the experiment. Encouragement, criticism or any other form of investment have been banned.

2.2.1. Immediate Post Concussion Assessment and Cognitive Testing (ImPACT)

The ImPACT is a computerized neuropsychological test battery designed to assess attention, memory, and processing speed. After completion of the test, five composite scores as well as a total score are generated, including verbal memory, visual memory, visual motor speed, reaction time, and impulse control [39]. The ImPACT has high convergent validity [40] as well as excellent sensitivity and specificity [41] in college athlete populations.

2.2.2. BMI Calculation

BMI was calculated from self-report of height and weight collected during the demographic section of the ImPACT. Weight and height were measured among participants in an upright position, wearing light clothing and bare foot. The size of the subjects was measured using a stadiometer, to the nearest centimeter. Subjects were also weighed on scales Seca (alpha model 770). 100 grams. Overweight was defined as a body mass index (BMI [weight/height²]) ≥ 25.

2.3. Statistical analyses

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All statistical tests were processed using STATISTICA Software (StatSoft, France).

To check whether a higher BMI was associated with lower performance on composite scores of the ImPACT. A Pearson correlation study was conducted to identify the relationship between BMI and composite scores of the ImPACT. Statistical significance was set at p < 0.05.

III. RESULTS

Table 2. Correlations between BMI and composite scores for rugby players

<table>
<thead>
<tr>
<th></th>
<th>BMI</th>
<th>Verbal memory</th>
<th>Visual memory</th>
<th>Visual motor speed</th>
<th>Reaction time</th>
<th>Impulse control</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>-</td>
<td>-0.181**</td>
<td>-0.172**</td>
<td>-0.103*</td>
<td>0.015</td>
<td>0.024</td>
</tr>
<tr>
<td>Verbal memory</td>
<td>-</td>
<td>0.527***</td>
<td>0.318***</td>
<td>-0.141*</td>
<td>-0.082</td>
<td></td>
</tr>
<tr>
<td>Visual memory</td>
<td>-</td>
<td>0.372***</td>
<td>-0.186**</td>
<td>-0.350***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual motor speed</td>
<td>-</td>
<td>-0.384***</td>
<td>-0.276***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction time</td>
<td>-</td>
<td></td>
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<td>Impulse control</td>
<td>-</td>
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*Significant at p ≤ 0.05.  
**Significant at p ≤ 0.01.  
***Significant at p ≤ 0.001.

The intercorrelations matrix between BMI and the five ImPACT composite scores showed that BMI is negatively correlated with verbal memory (r= -0.181; p<0.01), visual memory (r= -0.172; p<0.01) and visual motor speed (r= -0.103; p<0.05).

Also, the results showed that there was no significant correlation between BMI and reaction time or between BMI and impulse control.

IV. DISCUSSION

The aim of this study is to investigate the relationship between body mass index and cognitive performance in rugby players.

The findings of the current study indicate that BMI is negatively associated with cognitive function in a sample expected to have better than average cardiovascular fitness. BMI was found to be associated with reduced cognitive performance in rugby players, but only in specific areas of functioning. Notably, measures of memory had the greatest associations with BMI while no association was found on measures related to executive function and attention.

One factor that may be responsible for these differential effects is cardiovascular fitness. Cardiovascular fitness is known to have a beneficial effect on cognitive functioning [42], including measures of executive function [43] and attention [44]. Such findings raise the possibility that fitness helps to moderate the effects of BMI on some aspects of cognitive function (i.e. memory) but not others (i.e. executive function).

The results of the current study indicate that BMI is related to poor cognitive function but the exact mechanisms for this association are unclear. It is possible that athletes with a high BMI who over exert themselves are more likely to exhibit impaired performance on testing.

Other possibilities include the known physiological effects of higher BMI, including reduced glycemic control [45] and even reduced perfusion to the frontal brain regions [46]. Future prospective studies are needed to clarify the underlying mechanisms which may be at work, especially studies quantifying physical activity level.

The current study is limited in several ways. An important limitation for the current study involves the manner in which BMI was quantified. BMI is known to be limited in several ways, including poor adjustment for demographic factors (e.g. age, sex), concerns regarding the cut-points for BMI groups, and failure to directly measure body fat [47]. As a result, an individual can be lean with high muscle mass and may still be classified as obese according to BMI. This concern may be particularly relevant in a sample of athletes. However, it is noteworthy that greater BMI was still associated with poorer cognitive function in the current sample, despite these concerns.

The majority of studies, both in adults and children, found that overweight/obesity was associated with reduced cognitive ability and school outcomes [48, 49, 50, 51]. In a large group of children and adolescents between 8 and 16 years of age, overweight/obese performed poorly in tests measuring visuospatial organization and general mental ability even after adjusting for a number of potential confounders [51].

However, some studies show a continuous relationship between BMI and cognitive performance that is not limited to overweight players. Alternatively, obesity could have some adverse effect on brain function, possibly due to the secretion of hormones, pro-inflammatory cytokines or growth factors by adipose tissue that can cross the blood brain barrier [52].

Cournot et al. [53] showed that the performance of individuals with high body mass index were lower than those of low BMI individuals. For example, when the memory test, subjects whose BMI was 20 kg / m² retained an average of 9 out of 16 words, while those with a BMI ≥ 30 kg / m² or remembered only 7 words. In addition, high BMI appear to be associated with

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a slight decline in memory over 5 years. These results were obtained after elimination of many potential biases, including the level of education of the subjects, the presence of diabetes or high blood pressure, factors that could affect the results.

However, available evidence suggests that obesity among adults in the general population is associated with decreased cognitive performance [53], independent of age and comorbid metabolic disorders (e.g., hypertension, diabetes type 2) [54, 55]. Notwithstanding the longitudinal progression of cognitive decline, decreased cognitive performance has been reported to occur more rapidly among individuals with metabolic abnormalities (e.g., metabolic syndrome) when compared to individuals with normal metabolic profiles [56, 57].

Physical exercise does not seem to systematically induce positive effects on cognitive functioning. Thus, some research suggests differential effects depending on the age of the participants [31], nature [32, 26] and the amount of exercise [33, 34, 27, 28].

V. CONCLUSION

In summary, the results of the present study indicate that higher BMI is associated with reduced verbal and visual memory in rugby players.

Further work is needed to identify the mechanisms by which obesity adversely impacts cognitive function, particularly studies involving neuroimaging.

Physical activity has beneficial effects on the vascular system, including reduction of atherosclerotic plaque accumulation [58], decreased blood pressure [59], and subsequent reduction of cardiovascular disease risk [60].

However, a sporting activity is necessary to limit the diseases related to obesity and improve cognitive performance.

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