Retrospective Comparision of Regular Badminton and Closed-Skills Sports Participation on Cognitive Function in the Elderly: A Preminilary Analysis

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Abstract The occurrence of cognitive impairment has been associated with adverse outcomes including disability, morbidity, and mortality. However, the extent to which habitual badminton participation can benefit cognitive and physical function in the elderly is not clearly understood. We conducted a cross-sectional and retrospective comparison of multi-domain cognitive and physical function assessments between older adults who are long term participants in badminton and their sedentary counterparts. We compared cognitive (working memory, executive function, depression, and aging) between older, regular badminton players (RBPs) and age- and weight-matched sedentary elderly participants (SEPs). Relative to the CSPs, the RBP group displayed enhanced working memory and improved executive function, as evidenced by shorter response times ($P<0.05$) in the Sternberg working memory task, the Stroop task, and the Trail-Making Task. This study supports the hypothesis that elderly individuals who regularly play badminton exhibit superior cognitive performance compared to their age- and weight-matched sedentary counterparts. This is the most comprehensive study to date presenting data about the potential of badminton to benefit health in elderly population. These results represent an important initial step in elucidating the effectiveness of badminton as a health-promotion strategy, encouraging the elderly to engage in regular physical activity and minimize sedentary behaviors.

Keywords Cognitive performance, Badminton, Sedentary, Older adults

1. Introduction

The association between physical activity and cognitive function in older adults has been a focal point of countless research endeavors over the past several decades. With a rapidly graying world population, statistics indicate the number of adults aged 65 and above is projected to double from 703 million globally in 2019 to 1.5 billion by 2050 [1]. This dramatic demographic shift necessitates a comprehensive understanding of the lifestyle factors and interventions that can positively impact cognitive health and reduce the risk of neurodegenerative diseases in this growing elderly population. The importance of physical activity becomes even more prominent considering several recent longitudinal studies that demonstrate regular moderate-intensity physical activity can reduce the risk of cognitive decline, Alzheimer's disease, and other dementias by up to 30% in adults aged 65 and over [2]. However, emerging research also suggests the specific nature and cognitive demands of physical activity may play a crucial role in determining the degree of cognitive benefit. While many sports and exercises focus primarily on the physical and motor aspects of performance, other activities like racquet sports require a high degree of complex cognitive effort in addition to physical exertion.

Badminton, a racquet sport played between two opposing players or pairs on opposite halves of a court, has a estimated global participation base of over 330 million regular players worldwide across 188 countries, ranking as the second most participated sport globally after soccer [3]. The fast-paced, unpredictable nature of badminton necessitates rapid decision-making, sustained attention, and visual focus, working memory to track and anticipate opponent motions and patterns, and quick reflexes to react instantly to the dynamic stimuli of the shuttlecock's continuously changing trajectory. These constant cognitive demands inherent in badminton gameplay are instrumental in enhancing a wide range of cognitive skills including processing speed, visuospatial processing, executive function, motor planning, and reaction time [4]. In fact, one recent study found national league badminton players demonstrated significantly faster visual and auditory reaction times compared to age-matched athletes from closed-skill sports such as running, rowing, and swimming [5]. Maintaining quick reaction time and cognitive processing speed becomes increasingly vital for functional independence as we age, considering that studies show the average 65-year-old adult exhibits reaction times at least 20% slower on cognitive tasks compared to the average 25-year-old [6].

In contrast to the constantly changing environment and emergent situations encountered during badminton, closed-skills sports, and exercises such as running, swimming, cycling, or rowing on a controlled machine occur in a relatively stable, predictable environment and are often performed at a consistent, self-determined pace and intensity [5]. The primary emphasis in closed-skills sports is on technique, form, physiological capacity, and repetition rather than quick reactions or complex cognition. As a result, these types of self-paced activities are often regarded as less cognitively demanding overall than open-skilled sports like badminton, tennis, basketball etc. that require complex perception, anticipation, decision-making and reactions [7]. However, the inherently lower cognitive demands and lack of cognitive challenge during participation in most closed-skills sports limit their potential cognitive benefits, which may be a crucial disadvantage for elderly populations already experiencing age-related cognitive decline.

Multiple domains of cognitive function are known to undergo gradual decline with advancing age, even in healthy adults without dementia. Processing speed and reaction time exhibit a notable decrease, with longitudinal studies estimating processing speed declines at a rate of approximately 15% per decade after age 60 [8]. Memory function also displays age-related deterioration, with older adults frequently displaying measurable deficits in performance on tasks of working memory and episodic memory compared to younger cohorts [9]. Given the relatively high and increasing prevalence of Alzheimer's disease and related dementias in adults over 65, with recent statistics indicating approximately 25% of people aged 85 and above suffer from dementia [1], examining the potential cognitive benefits from regular participation in highly demanding cognitive-physical activities such as badminton could offer valuable insights to inform preventative strategies. Especially considering extensive research has demonstrated engagement in cognitively stimulating leisure activities is associated with a reduced risk of dementia by 30-50% in older adults [10].

Studies report that Malaysia has one of the most rapidly growing aging populations in Southeast Asia, with the number of people aged 65 and above projected to reach 15% of the total population by 2030 [11]. Similarly, the elderly population across Asia is expected to more than double from 395 million in 2019 to over 840 million by 2050 [12]. However, participation in regular physical activity remains low in Malaysian and many other Asian elderly cohorts, with only 30-40% engaging in sufficient exercise [13]. Badminton's popularity across Malaysia and many other Asian nations presents a unique opportunity to promote this highly stimulating cognitive-physical activity to enhance brain health in our rapidly growing elderly populations. Given badminton's widespread appeal and accessibility across Malaysia and Asia [3], this research could inform public health campaigns to increase badminton participation as an engaging lifestyle intervention to potentially reduce risk of dementia and maintain cognitive vitality in Asian elderly populations.

This paper will provide a retrospective, cross-sectional comparison of performance on assessments of cognitive function including processing speed, executive function, memory, visuospatial skills, and attention in three groups of otherwise healthy elderly individuals aged 65 and above: 1) regular recreational badminton players with 5+ years participation, 2) active individuals participating regularly in predominantly closed-skills sports and exercises like running, swimming, or cycling with no prior badminton experience, and 3) sedentary controls not engaged in any regular exercise program.

2. Methods

2.1. Participants

A cross-sectional observational study was carried out in Negeri Sembilan, focusing on the comparison of regular badminton players (RBPs) and individuals engaged in closed-skilled exercises (CSEs) such as running, cycling, or swimming. The study also incorporated a control group of sedentary elderly participants (SEPs). A total of 151 participants aged above 55 were initially evaluated for the RBP group. After comprehensive testing, questionnaire completion, and cognitive function measurement, 36 participants (21 males and 15 females, ages ranging from 55 to 69 years) were finalized [14]. An equivalent number of eligible age- and weight-matched participants were voluntarily enlisted for the CSE and SEP groups. This study was approved by the Research Ethics Committee (REC) of the Research Management Institute (RMI) at Universiti Teknologi MARA (UiTM, 600-TNCPI5/1/6) and was conducted in strict adherence to the guidelines delineated in the Helsinki Declaration (2013).

2.2. Study Protocol

Eligible participants who successfully completed a screening process overseen by a medical assistant, were required to report to the Physiology and Nutrition Laboratory at the Faculty of Sport Science and Recreation, Universiti Teknologi Mara, Malaysia. Upon their arrival, the participants received a comprehensive briefing concerning the objectives and procedures of the test.

After the briefing, the participants were instructed to begin the cognitive function assessment, which included a working memory test consisting of the Sternberg working memory task. After completing the working memory test, the executive function assessment was conducted using the Trail

Making Test (TMT) and the Stroop test [15]

Lastly, before leaving the testing center, participants were asked to complete several structured questionnaires. These included the Global Physical Activity Questionnaire (GPAQ), a modified version of the Physical Activity Scale for the Elderly (PASE), the Depression Anxiety Stress Scale (DASS-21), and the Montreal Cognitive Assessment (MoCA) [11]

2.3. Measurement

Participant anthropometrics, including weight and height, were assessed via a validated stadiometer (Seca 220; Seca, Ltd, Hamburg, Germany) for BMI calculation. Waist circumference, measured at the midpoint between the lowermost rib and uppermost iliac crest using the Seca 201 tape, facilitated the computation of the waist-to-hip ratio.

Working memory was evaluated via the N-back and Sternberg tasks. The former task, a computerized test, necessitated persistent mental set updates in response to prior stimuli, with performance assessed in terms of accuracy and response time. The Sternberg task, administered via Inquisit® version 6.0, entailed a sequence of two to five digits displayed at 1200 millisecond intervals.

Executive function was assessed using the Trail Making Test (TMT) and the Stroop test, both executed on Inquisit® version 6.0. The TMT, measuring attention variables, required the sequential connection of randomly arranged circles, with TMT-B involving an alternation between numbers and letters. The Stroop test necessitated rapid, accurate responses to text strings.

Cognitive aging was measured via the Montreal Cognitive Assessment (MoCA), a comprehensive cognitive function tool covering domains like memory, visuospatial skills, executive function, attention, and language. A score of 26 out of 30 was indicative of mild cognitive impairment. Negative emotional states were evaluated using the Depression, Anxiety, and Stress Scale (DASS-21), with participants rating their agreement with given statements.

24. Data Analysis

A descriptive statistic was used to identify the basic descriptive characteristics of the participants. To probe the differences in cognitive function (working memory, executive function, aging, and depression), a one-way repeated measures ANOVA was conducted using Brown-Forsythe and Welch tests. In depth scrutiny of the differences was performed using Dunnett's T3 multiple comparison tests. Where any significant differences are detected, 95% confidence intervals were presented to show the probable spectrum of the real value in the sample population. Furthermore, partial eta squared (ηp2) and Cohen's d (dz) is presented, with value of trivial (0 – 0.19), small (0.20 – 0.49), moderate (0.50 – 0.79), or large (> 0.80) were used to describe the effect size. GraphPad Prism software (version 9.0, GraphPad Software Inc., La Jolla, California, USA) was used for all data analysis, with statistical significance accepted at $p < 0.05$.

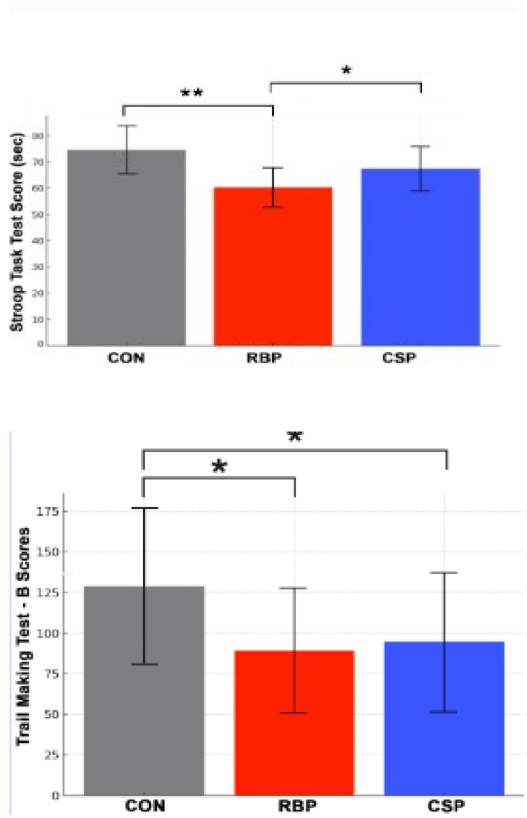

Figure 1. Differences in Trail-Making Task scores (TMT) and Stroop task (s)

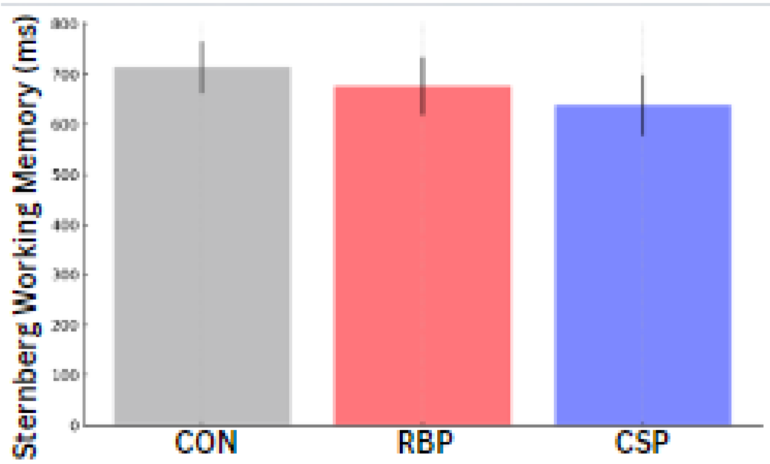

Figure 2. Differences in Sternberg working memory.

Table 1. Differences in MoCA score and DASS-21between RBP, CSP and CON group.

Parameter	RBP	CSP	CON
MoCA score	26.7 ± 1.9	25.4 ± 3.6	26.8 ± 2.3
DASS-21	1.95 ± 2.13	1.87 ± 2.35	2.14 ± 2.7

2.5. Results

2.5.1. Executive Function

Figure 1 presents the differences Trail Making Test and Stroop task. A follow up test revealed that RBP and CSP group displayed a better Trail making test scores. As for reaction time scores in Stroop's test, RBP shows a slightly better result compared to CSP ($p<0.05$) and substantially greater test scores when compared to CON group ($p<0.05$)

2.5.2. Working Memory

Figure 2 shows the differences in Sternberg working memory. A follow up test revealed that RBP and CSP group demonstrated a better Sternberg working memory compared to CON group ($p<0.05$)

2.5.3. Depression, Anxiety, Stress & Aging

For the MoCA (measure of aging), no significant differences were found for all three groups (Table 1; $p>0.05$). As for the DASS-21, no significant differences were found between RBP and CSP, but there are significant differences between RBP, CSP on CON group.

2.6. Discussion

To the best of author's knowledge, this is the first study to assess the comparison of regular badminton and closed-skills sports participation on cognitive function in the elderly. In this cross-sectional observational analysis, our current results imply that the elderly-lifespan of individuals who spend more time involved in badminton-playing may exhibit better performance in cognitive function. Regular engagement in physical activities could be a crucial component in averting chronic diseases among the elderly population. Badminton stands as a globally revered sport, relished by individuals across various age groups. The intermittent nature of the game exerts substantial demands on both the aerobic and anaerobic systems, with the alactic anaerobic system contributing more significantly than the lactic anaerobic energy contribution[16]. This involves a total play duration of approximately 30–50 minutes, comprising of intense bursts lasting 4–8 seconds, interspersed with brief rest intervals of 5–15 seconds [17]. It has been irrefutably established that the work density (the ratio of active playtime to rest duration) in badminton exceeds that of other high-intensity team sports, such as soccer.

The beneficial effect of regular physical activity on working memory has been previously demonstrated by (*ref). The present study found that RBP and CSP have a better performance for Sternberg working memory task compared to CON group. An increasing body of evidence suggests that physical activity, such as aerobic exercise, enhances cognitive functions, with a particular emphasis on cognition reliant on the prefrontal cortex [18]. Regular physical activity has been demonstrated to augment the volume of the hippocampus, prefrontal cortex, and basal ganglia, thereby optimizing brain function, and boosting overall cognitive performance[15], [19]. [19] reported a correlation between physical activity, fitness, and increased bilateral hippocampal volume. Improved fitness and larger hippocampal volume were found to be linked with superior spatial memory performance. Studies employing Functional Magnetic Resonance Imaging to assess brain connectivity propose that the brains of older adults who maintain higher levels of fitness operate more efficiently than those of less fit counterparts [20], [21]

Based on the types of sport (open-skilled and closed-skilled), our results showed that participating in badminton groups were positively associated with Trail making test and Stroop task in healthy elderly. The RBP showed significantly faster reaction time in Stroop task compared to CSP. [22] reported that elderly racket sports players with at least 20 years of experience, had a 3.1% faster simple reaction time and 6.1% faster choice reaction time, when compared to a running group [22]. The badminton groups also did show improvement in Trail-making test, compared to the closed-skilled and control groups. Consistent with current results, a previous study reported there are significant differences in executive function between open-skilled and closed-skilled sport groups of elderly people (mean = 69.4). A cross-sectional comparing passive (seldom requires manipulation) and active (requires manipulation) visuospatial working memory found that only open-skilled exercisers had greater passive Trail making test than the sedentary group [5].

Furthermore, our findings reveal superior DASS-21 scores in the RBP and CSP groups when contrasted with the Control CON group. The practice of regular physical activity is emerging as an optimal non-pharmacological strategy to mitigate age-associated decline and alleviate anxiety in the elderly population [23]. An accruing body of evidence highlights the role of physical activities, such as aerobic exercises, in attenuating stress, anxiety, and depression. Routine engagement in physical activities has been demonstrated to reduce stress levels and enhance overall cognitive functioning. Despite these insights, the current study was unable to discern any significant differences in the Montreal Cognitive Assessment (MoCA) results across the three groups, the underlying reasons for which remain elusive. It is suggested that a more accurate appraisal of an individual's cognitive capabilities, particularly in an aging population, may require the use of multiple psychometric tests that probe different aspects of aging.

3. Conclusion

In conclusion, this study demonstrates that regular participation in badminton and closed-skills sports may enhance cognitive function in elderly individuals, highlighting the importance of physical activities for cognitive health. Badminton, due to its superior work density and unique aerobic and anaerobic demands, appears to offer significant cognitive benefits. While participants in these physical activities showed better working memory and lower levels of stress, anxiety, and depression, no significant differences were found in the Montreal Cognitive Assessment results across the groups. This suggests that a more comprehensive evaluation of cognitive function might be necessary. The findings underscore the potential of regular physical activity, particularly badminton, in promoting cognitive health and wellbeing among the elderly, though further research is required to optimize these interventions.

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