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Patterns of Mentally Active versus Passive Sedentary Behavior in Adults: Post-COVID-19 Insights

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Abstract: Background: Although sedentary behavior (SB) before and during COVID-19 has been studied, mental activity-based SB patterns have been overlooked. This secondary analysis investigated the patterns of mentally active vs. passive SB in adults post-COVID-19 pandemic and examined sex differences. Methods: Adults (n = 1255; 45% males; 50% aged between 20 and 29 years old) self-reported general characteristics, anthropometric and socioeconomic variables, and mentally active and passive SB (weekdays and weekend days) using a structured web-based survey. Adjusted ANCOVA on Ranks tests assessed differences between mentally active and mentally passive SB during the day, on weekdays, and weekend days. Adjusted Quade Nonparametric ANCOVA tests evaluated these differences in males vs. females. Results: Adults significantly spent greater time in mentally active vs. passive SB (5.61 $\pm$ 4.57 vs. 2.50 $\pm$ 3.25; $p < 0.001$). Mentally active SB was more prevalent on weekdays than on weekends (6.00 $\pm$ 5.00 vs. 5.00 $\pm$ 5.00; $p < 0.001$). No significant difference was observed for mentally passive SB ($p > 0.05$). Males significantly accumulated more mentally active SB compared to females ($p < 0.001$ for all). Females significantly spent more time in mentally passive SB on weekdays than males ($p < 0.05$). Conclusion: Our results highlight the need for individualized SB reduction strategies based on mental activity to obtain the most benefits of SB reduction interventions and promoting overall health post-COVID-19 pandemic.

Keywords: post-COVID-19; lifestyle; mental activity; sedentary behavior; Saudi Arabia

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1. Introduction

In March 2020, COVID-19, a respiratory disease caused by the coronavirus, was declared a pandemic [1]. This disease has resulted in 6 million deaths globally [1]. The coronavirus has not only invaded the respiratory system but also caused multiple health complications such as impaired cognitive functions (e.g., impaired higher mental thinking skills) [2,3]. During the recovery phase, these impairments may persist [4] leading to what was coined 'long-COVID' [5], necessitating comprehensive health and lifestyle interventions.

During the COVID-19 pandemic, many governments have implemented restrictive measures such as social distancing and lockdowns [6]. While these measures have helped reduce the spread of the disease, they also have unfavorably altered physical behavioral patterns in many populations [7]. For example, during the lockdowns, data showed a decline in physical activity (PA) and an increase in sedentary behavior (SB), defined as low-energy expenditure activity (i.e., $\leq$1.5 MET) during wakefulness in a seated, laying, or reclining posture [7,8]. Notably, these changes have had greater impacts on females compared to males (e.g., females accumulated more SB compared to males) [9]. As a result, SB, in particular, was a major and feasible target during the COVID-19 pandemic [10]. Of significant importance, new research has revealed that the recent lifestyle reshaping including low PA and high SB due to COVID-19 is likely to continue for several years [11]. Put together, it is crucial to assess the prevalence and pattern of SB post-COVID-19 pandemic to comprehensively understand the best SB reduction strategy to confront COVID-19 ramifications.

To promote a healthy lifestyle during and possibly post-COVID-19, national and international physical behavior recommendations were advocated [12–14]. Of particular relevance, the Saudi government has launched the first 24-Hour Movement Guidelines for adults in Saudi Arabia [15]; adults are recommended to reduce excessive SB during the day by breaking prolonged sitting periods with light PA [15]. However, these guidelines, as well as the international SB recommendations [16], do not specify the type of SB that should be the main target to acquire the maximum health benefits [15]. Although it remains overlooked, emerging evidence indicates that different types of SB appear to have varying impacts on both mental and physical health [17,18]. For instance, SB that involves mental activity (e.g., performing occupational tasks while sitting or reading a book) was correlated to lower odds of being overweight and physically inactive whereas SB that does not involve mental activity (e.g., TV viewing or sitting and listening to music) was found to associate with higher odds of being overweight or physically inactive [19]. Furthermore, a recent meta-analysis of twelve prospective studies revealed direct significant associations between mentally passive SB (i.e., TV watching) and the risk of depression; yet no such association was observed with mentally active SB (i.e., computer use) [20]. This distinct relationship between different types of SB and healthy outcomes could have potential implications for health measures during and post-COVID-19 [21]. Given that the lifestyle reshaping due to COVID-19 such as increased time spent in SB is likely to persist post-COVID-19 [11], the viewpoint of assessing SB based on mental activity becomes critical. Thus, it is important to characterize and examine the patterns of SB based on mental activity to construct effective SB reduction interventions for Saudi adults post-COVID-19 pandemic.

Therefore, this secondary analysis aimed to (1) determine the pattern of mentally active vs. passive SB in adults post-COVID-19 pandemic and (2) compare the pattern of these types of SB in male vs. female adults. It was hypothesized that mentally active SB would be more prevalent compared to mentally passive SB, that mentally active SB would be greater during weekdays compared to weekend days, and that mentally passive SB would be greater on weekend days compared to weekdays. In addition, it was hypothesized that females would generally accumulate more active and passive SB compared to males.

2. Materials and Methods

2.1. Study Design

This study was a secondary analysis of the Saudi Post-COVID-19 Sedentary Behavior Study (SPSB) [22]. Briefly, the SPSB was a structured web-based, cross-sectional investigation that aimed to determine the prevalence, patterns, and determinants of SB among Saudi adults post-COVID-19 pandemic. SB data were collected by using a self-report instrument (The Sedentary Behavior Questionnaire [SBQ]) between 2 December 2022 and 25 January 2023. The SBQ as well as standardized questionnaires to measure general characteristics were distributed to potential participants via the (anonymous by the journal) University's emails and the most utilized social media platforms in Saudi Arabia (i.e., Snap Chat, WhatsApp, Instagram, and X) [23].

2.2. Measurements

General Characteristics, Anthropometric and Socioeconomic Variables

The standardized questionnaires that were used in this study asked the respondents to report their age (i.e., $\geq$50, 49 to 40, 39 to 30, or 29 to 20 years old), sex (i.e., male or female), whether they were smoking (i.e., yes or no), and whether they were diagnosed with any chronic disease (i.e., yes or no). Furthermore, these questionnaires asked the participants to recall their last measured body weight (kilogram [kg]) and height (centimeter [cm]). Then, the body mass index (BMI) was calculated as follows: BMI (kg/m^2) = body weight (kg)/body height (m^2). In addition, information about the highest degree (i.e., diploma or less, undergraduate, or postgraduate) and current occupation (i.e., employed, currently unemployed, or student) was also collected by these questionnaires.

2.3. Sedentary Behavior

The Arabic version of the SBQ [24–26] was used to assess time accumulated in mentally active and passive SB. The SBQ consists of 18 SB questions (i.e., 9 questions for weekdays and 9 questions for weekend days). It asked the participants to report time (h/day) spent in the following SB on weekdays and on weekend days: (1) sitting and listening to music, (2) watching TV, (3) playing computer or video games, (4) playing a musical instrument, (5) sitting and reading a book or magazine, (6) doing artwork or crafts, (7) sitting and talking on the phone, (8) doing paperwork or computer work (office work, emails, paying bills, etc.), and (9) sitting and driving a car, bus, or train [24]. Using the framework for classifying SB based on its type [27], sitting and listening to music and watching TV were categorized as mentally passive SB because these do not require higher mental thinking skills. On the other hand, the remaining 7 questions (i.e., playing computer or video games, playing a musical instrument, sitting and reading a book or magazine, doing artwork or crafts, sitting and talking on the phone, doing paperwork or computer work [office work, emails, paying bills, etc.], and sitting and driving a car, bus, or train) were classified as mentally active SB as they require higher mental thinking skills.

After classifying these SBs into active or passive SB, we estimated mentally active SB (h/day) per weekday by aggregating time spent in mentally active SB on a weekday, and mentally active SB (h/day) per weekend day by aggregating time spent in mentally active SB on a weekend day. Then, we estimated the overall mentally active SB (h/day) by using the following formula: (mentally active SB per weekday $\times$ 5) + (mentally active SB per weekend day $\times$ 2)/7. Furthermore, we estimated mentally passive SB (h/day) per weekday by summing time spent in mentally passive SB on a weekday, and mentally passive SB (h/day) per weekend day by combining time spent in mentally passive SB on a weekend day. Thereafter, we estimated the overall mentally passive SB (h/day) by utilizing the following formula: (mentally passive SB per weekday $\times$ 5) + (mentally passive SB per weekend day $\times$ 2)/7 [22].

2.4. Statistical Analyses

The original study calculated the sample size that was required to represent adults in Saudi Arabia by utilizing the Raosoft calculator (Raosoft Inc., Seattle, WA, USA) [22]. It was revealed that at least 385 adults were needed. However, the final number of the included participants in the original study was 1255 adults. Data from all these participants were used in the current secondary analysis. Therefore, this secondary analysis was statistically well-powered to represent adults in Saudi Arabia.

The characteristics of these participants including age, sex, degree, occupation, current smoking status, and chronic disease status were reported as frequencies and percentages or means and standard deviations, as appropriate. Mentally active and passive SB (i.e., overall, per weekday, and weekend day for both types of SB) were checked for normality and were found to have non-normal distributions. As such, nonparametric test approaches were implemented to evaluate the hypotheses of this secondary analysis as follows. First, all outcome variables (SB variables) were rank-transformed using the 'RANK' function. Then, ANCOVA on Ranks (ANCOVA-R) tests assessed differences between mentally active and mentally passive SB during the day in adults while adjusting for confounders (i.e., age, sex, BMI, degree, occupation, and chronic disease status) [28]. The same tests were also utilized to compare mentally active and passive SB on weekdays vs. on weekend days while controlling for the same confounders. Thereafter, Quade Nonparametric ANCOVA tests evaluated differences between mentally active and mentally passive SB in male vs. female adults while adjusting for confounders (i.e., age, BMI, degree, occupation, and chronic disease status). In addition, the same tests were used to compare mentally active vs. passive SB on weekdays vs. on weekend days by sex and controlling for the same confounders. The rank-biserial correlation (r_B) was used to assess the effect size for these differences as follows: large if r_B = 0.5, medium if r_B = 0.3, and small if r_B = 0.1. The SPSS software

(SPSS 28.0 Version, SPSS Inc.) was utilized to perform these statistical analyses, and the significant level was set as p-value < 0.05.

3. Results

3.1. Participants

Table 1 displays the general characteristics of the included participants in the current analyses (n = 1225). These participants tended to be young-to-middle-age adults and about half of them were females (55.0%). These participants also appeared to be healthy, highly educated, either employed or student, and not current smokers.

Table 1. Participant characteristics (n = 1255).

Characteristic	Mean (SD)/n (%)
BMI (kg/m^2)	26.2 ± 6.7
Age	
20 to 29 years old	633 (50.4%)
30 to 39 years old	318 (25.3%)
40 to 49 years old	194 (15.5%)
50 years old or older	110 (8.8%)
Sex	
Male	565 (45.0%)
Female	690 (55.0%)
Degree	
Diploma or Less	286 (22.8%)
Undergraduate	644 (51.3%)
Postgraduate	325 (25.9%)
Occupation	
Employed	586 (46.7%)
Currently Unemployed	140 (11.2%)
Student	529 (42.1%)
Currently Smoking	
No	1075 (85.7%)
Yes	180 (14.3%)
Chronic Disease	
No	988 (78.7%)
Yes	267 (21.3%)

BMI; body mass index, kg/m^2; kilogram per meter squared, SB; sedentary behavior.

3.2. Aim 1: Determine the Pattern of Mentally Active vs. Passive SB in Adults Post-COVID-19 Pandemic

Table 2 and Figure 1 compare the patterns of mentally active vs. passive SB. As hypothesized, Saudi adults significantly spent greater time in mentally active SB as compared to mentally passive SB (Δ = 3.11 h/day; $p < 0.05$). These differences were more apparent on weekdays as compared to weekend days. Furthermore, the participants accumulated more time in mentally active SB on weekdays as compared to weekend days (Δ = 0.86 h/day; $p < 0.05$). Importantly, the effect sizes for these differences observed ranged from medium to large (r_B = 0.40 to 0.78). However, no significant difference was observed for mentally passive SB when comparing weekdays vs. weekend days ($p > 0.05$).

Table 2. Comparisons of the patterns of mentally active vs. passive SB.

Type of SB	M ± IQR	Δ	Z *p*	r_B
Mentally Active SB (h/day)	5.61 ± 4.57	3.11	821.79 <0.001	0.78
Mentally Passive SB (h/day)	2.50 ± 3.25			
Mentally Active SB on a weekday (h/day)	6.00 ± 5.00	3.75	851.15 <0.001	0.78
Mentally Passive SB on a weekday (h/day)	2.25 ± 3.00			
Mentally Active SB on a weekend day (h/day)	5.00 ± 5.00	2.75	439.33 <0.001	0.67
Mentally Passive SB on a weekend day (h/day)	2.25 ± 3.00			
Mentally Active SB on a weekday (h/day)	6.00 ± 5.00	1.00	42.71 <0.001	0.40
Mentally Active SB on a weekend day (h/day)	5.00 ± 5.00			
Mentally Passive SB on a weekday (h/day)	2.25 ± 3.00	0.00	0.002 0.965	−0.07
Mentally Passive SB on a weekend day (h/day)	2.25 ± 3.00			

All ANCOVA-R tests were adjusted for age, sex, BMI, degree, occupation, and chronic disease status. IQR; interquartile range, M; median, r_B; the rank-biserial correlation, SB; sedentary behavior, *p*; *p*-value, Z; z statistics, Δ; the difference between the two types of SB.

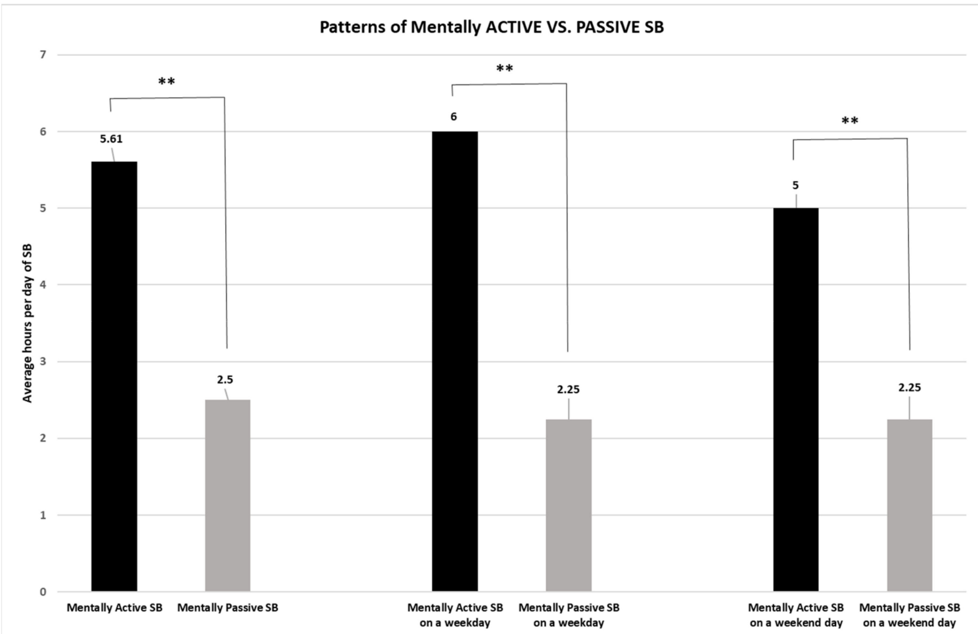

Figure 1. Patterns of mentally active vs. passive SB. All ANCOVA-R tests were adjusted for age, sex, BMI, degree, occupation, and chronic disease status. SB; sedentary behavior, **; *p*-value < 0.05.

3.3. Aim 2: Compare the Pattern of Mentally Active vs. Passive SB in Males vs. Females

Table 3 and Figure 2 compare the patterns of mentally active vs. passive SB by sex. In contrast to our hypothesis, Saudi females and males accumulated comparable and not statistically significant time in mentally passive SB ($\Delta = -0.35$ h/day; $p = 1.01$). Once the type of the day of the week was classified into a weekday or weekend day, a significant sex difference in mentally passive SB emerged such that males accumulated less mentally passive SB on weekend days as compared to females ($\Delta = -1.00$ h/day; $p < 0.05$). On the other hand, Saudi males significantly spent more time in mentally active SB as compared to Saudi females ($\Delta = 1.07$ h/day; $p < 0.05$). These differences were larger on weekend days as compared to weekdays. Notably, all these differences observed between sexes had small effect sizes ($r_B = 0.06$ to 0.17).

Table 3. Comparisons of the patterns of mentally active vs. passive SB by sex.

Variable	Males M ± IQR	Females M ± IQR	Δ	Z *p*	r_B
Mentally Active SB (h/day)	6.25 ± 4.57	5.18 ± 4.54	1.07	19.26 <0.001	0.14
Mentally Passive SB (h/day)	2.29 ± 3.07	2.64 ± 3.25	−0.35	2.69 0.101	−0.08
Mentally Active SB per weekday (h/day)	6.25 ± 5.25	5.50 ± 4.75	0.75	13.74 <0.001	0.12
Mentally Passive SB per weekday (h/day)	2.00 ± 3.00	2.38 ± 3.25	−0.38	1.37 0.243	−0.06
Mentally Active SB per weekend day (h/day)	5.50 ± 4.75	4.25 ± 5.00	1.25	29.41 <0.001	0.17
Mentally Passive SB per weekend day (h/day)	2.00 ± 3.25	3.00 ± 3.44	−1.00	6.95 0.008	−0.11

All Quade Nonparametric ANCOVA tests were adjusted for age, BMI, degree, occupation, and chronic disease status. IQR; interquartile range, M; median, r_B; the rank-biserial correlation, SB; sedentary behavior, *p*; *p*-value, Z; z statistics, Δ; the difference between males and females.

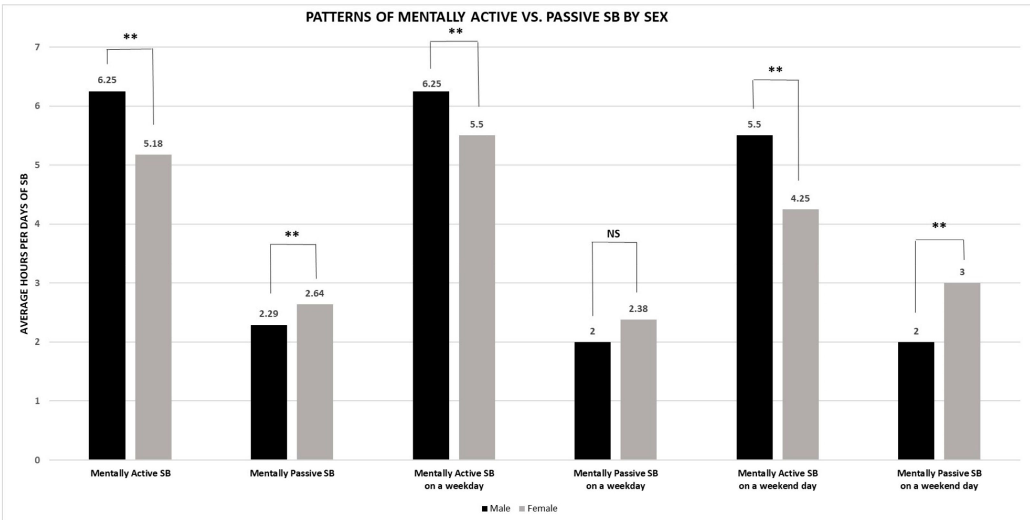

Figure 2. Patterns of mentally active vs. passive SB by sex. All Quade Nonparametric ANCOVA tests were adjusted for age, BMI, degree, occupation, and chronic disease status. NS; not significant, **; *p*-value < 0.05, SB; sedentary behavior.

4. Discussion

The current study examined the patterns of active versus passive SB in adults in Saudi Arabia post-COVID-19 and explored whether these patterns vary by sex. As hypothesized, the results uniquely revealed that adults in Saudi Arabia spent more time in mentally active SB (e.g., doing work-related tasks) as compared to mentally passive SB (e.g., such as TV watching) post-COVID-19 pandemic. Moreover, large differences were observed between mentally active and passive SB on overall week, weekdays, and weekend days, ranging from 2.75 to 3.75 h. Whereas mentally active SB was more common on weekdays than on weekends, with a difference of 1.00 h. On the other hand, it was found that the patterns of mentally passive SB were not different when comparing weekdays vs. weekends. Remarkably, apparent SB difference patterns were observed between males and females; while males tended to engage in more mentally active SB, females spent more time in mentally passive SB on weekend days. These findings highlight the need for individualized SB reduction strategies based on mental activity for adults.

4.1. Comparison to the Literature: Aim 1

Before the COVID-19 pandemic, a few studies compared the patterns of different types of mentally active and passive SB in adults. For instance, one study found that British adults spent an average of 6.3 ± 1.8 h/day in mentally active SB, such as performing occupational tasks while sitting, and 1.5 ± 1.2 h/day in mentally passive SB, such as TV viewing [29]. Another study reported that French adults engaged in an average of 4.2 ± 3.1 h/day in mentally active SB (i.e., performing occupational tasks while sitting) and 2.2 ± 1.6 h/day in mentally passive SB (i.e., TV viewing) [30]. In our current study, we uniquely revealed that adults in Saudi Arabia spent a median of 5.61 ± 4.57 h/day in mentally active SB, such as sitting and reading a book or doing paperwork, after the COVID-19 pandemic. Additionally, they spent a median of 2.50 ± 3.25 h/day engaged in mentally passive SB, such as watching TV or listening to music. In summary, though COVID-19 had significant unfavorable impacts on SB globally, adults appear to consistently spend more time engaged in mentally active SB than mentally passive SB, regardless of COVID-19.

Of clinical significance, a recent meta-analysis of prospective studies involving 128,553 adults revealed that mentally passive SB significantly increases the odds of depression by 17%, independent of PA level [20]. In addition, the odds of being overweight increase by 34% when accumulating a higher amount of mentally passive SB [19]. No comparable negative associations were detected with mentally active SB [19,20]. Indeed, a recent longitudinal study suggested that spending more time in mentally active SB was significantly correlated to a lower risk of dementia [17]. These findings signify the importance of constructing SB interventions, particularly post-COVID-19 pandemic, based on mental activity. As adults in Saudi Arabia spend ~31% (i.e., 2.50 h/day) of their daily SB on mentally passive SB post-COVID-19 pandemic, researchers, policymakers, and decision-makers may focus on reducing mentally passive SB to enhance overall health and address the aftermath of COVID-19.

Notably, although we found that adults significantly accumulated greater time in mentally active SB on weekdays compared to on weekend days, they spent comparable time on mentally passive SB during both weekdays and weekend days. A possible explanation for the difference in this pattern between weekdays and weekend days is that work-related SB (i.e., a mentally active SB) significantly contributes to SB on weekdays and is then potentially replaced with light PA on weekend days. [31]. On the other hand, the opportunities to engage in mentally passive SB are similar on both weekdays and weekend days. As such, interventions that aim at reducing SB in adults should target mentally passive SB on both weekdays and weekend days. This approach is likely yield the greatest physical and mental health benefits, although further empirical examination is needed to confirm this hypothesis.

4.2. Comparison to the Literature: Aim 2

We also observed that male adults in Saudi Arabia engaged in more mentally active SB and less mentally passive SB compared to female adults. These findings were in agreement with a previous, population-based cross-sectional study of Latin Americans (n = 9218) [32]; Latin American male adults significantly spent greater time in mentally active SB (i.e., video gaming and riding in an automobile) compared to Latin American female adults. On the other hand, another population-based study found that Brazilian female adults tended to accumulate more time in mentally passive SB (i.e., TV viewing) compared to Brazilian male adults [33]. Together, these findings indicate that there are sex differences in the patterns of accumulating mentally active and passive SB. Therefore, it is essential to consider sex when developing strategies to address SB patterns in public health initiatives. Interventions aimed at reducing SB should be tailored not only according to mental activity levels but also to sex groups.

4.3. Clinical Significance

Although the 24-Hour Movement Guidelines for adults in Saudi Arabia emphasize reducing SB throughout the day during and after the COVID-19 pandemic [15], it does not specify whether adults should limit mentally active and/or passive SB. Our study adds to the growing body of research suggesting that engaging in mentally passive SB may have negative impacts on various health outcomes. Our findings, which are the first of their kind, indicate that adults in Saudi Arabia spent approximately 31% of their daily sedentary time engaging in mentally passive SB after the COVID-19 pandemic. Our research revealed that mentally passive SB is more prevalent in female adults (34%) as compared to male adults (27%). Based on our findings, it is recommended that policymakers and decision-makers focus on reducing mentally passive SB, particularly in female adults, to potentially derive the maximum health benefits from SB reduction interventions post-COVID-19 pandemic. This aligns with the current guidelines in this regard.

4.4. Strengths and Limitations

It is worth noting that the current study has certain strengths. For one, it was the first investigation in Saudi Arabia to examine the patterns of accumulating SB based on mental activity specifically in the post-COVID-19 pandemic era. Additionally, this study used a large sample (n = 1255 individuals), which ensures the statistical power of our analyses and improves the robustness of the study's findings. Furthermore, we made use of the most common social media platforms in Saudi Arabia to reach out to potential participants, thereby increasing the study's reach and enhancing the diversity of the study's sample. [23]. Thus, our findings can be generalized to the adult population in Saudi Arabia who have similar characteristics to our study's sample.

Yet, several important limitations exist and should be considered when interpreting our results. First, though this study was a population-based investigation, data were collected by using an online survey. This type of study design is usually prone to a few biases such as selection bias (i.e., where participants self-select to be included or not in the study leading to over-representation or under-representation of a particular group of the targeted population) [34]. Moreover, since participation in the study required internet availability and usage, our results may not apply to those who lack access to internet services. Lack of full attention and being easily disrupted while completing a web-based survey were not checked and could be a confounder that could have affected the current findings. In addition, because no existing objective devices currently can distinguish between different SB based on mental activity, the use of self-report instruments is necessary. Thus, mentally active and passive SB was estimated by using a self-report questionnaire (i.e., SBQ) only, which is also prone to random, systematic, and/or reporting errors [35]. For example, individuals can have memory lapses where they can unintentionally forget the exact number of hours spent in certain types of SB. Moreover, self-reported instruments also usually underestimate time spent in SB [36]. Therefore, it is crucial to develop a more factual approach and objective devices to measure mentally active and passive SB and to implement it in research and clinical settings. Additionally, another limitation of this study was that we measured mentally active and passive SB at only one interval (i.e., post-COVID-19). This limitation makes it difficult to comprehend whether the observed patterns were due to the COVID-19 pandemic or not. Together, future research should account for these potential confounders and biases to attain more comprehensive and stronger conclusions.

5. Conclusions

We uniquely assessed the patterns of mentally active vs. passive SB in adults in Saudi Arabia post-COVID-19 pandemic and examined sex differences. Our results found that adults generally spent more time engaged in mentally active SB compared to mentally passive SB and this was more apparent during weekdays. Moreover, Saudi female adults commonly spent greater time in mentally passive SB compared to Saudi male adults. In summary, the current findings support the recent Saudi efforts to reduce SB, especially post-COVID-19 pandemic [15]. Yet our results further highlight the need for individualized SB reduction strategies based on mental activity for adults. This may help in obtaining the most benefits of SB reduction interventions and promote overall health post-COVID-19 pandemic.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available upon request from the corresponding author.

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Conflicts of Interest: The authors declare no conflicts of interest.

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