Guideline

[1]The University Sleep Disorders Center, College of Medicine, King Saud University, Riyadh, Saudi Arabia, [2]National Plan for Science and Technology, College of Medicine, King Saud University, [3]Lifestyle and Health Research Center, Health Sciences Research Center, Princess Nourah Bint Abdulrahman University, Riyadh, Saudi Arabia, [4]Department of Exercise Physiology, College of Sport Sciences and Physical Activity, King Saud University, Riyadh, Saudi Arabia, [5]Department of Community Health Sciences, College of Applied Medical Sciences, King Saud University, Riyadh, Saudi Arabia, [6]Comprehensive Specialized Clinics for the Security Forces in Jazan, General Administration for Medical Services, Ministry of Interior, [7]Department of Physical Education, College of Sport Sciences and Physical Activity, King Saud University, Riyadh, Saudi Arabia, [8]Saudi Public Health Authority, Riyadh, Saudi Arabia

Address for correspondence:
Prof. Ahmed S. BaHammam, University Sleep Disorders Center, College of Medicine, King Saud University, Riyadh, Saudi Arabia.
E-mail: ashammam2@gmail.com

Submission: 20-01-2021
Accepted: 19-03-2021
Published: 20-07-2021

Access this article online

Quick Response Code:

Website:
www.thoracicmedicine.org

DOI:
10.4103/atm.atm_32_21

Joint consensus statement of the Saudi Public Health Authority on the recommended amount of physical activity, sedentary behavior, and sleep duration for healthy Saudis: Background, methodology, and discussion

Ahmed S. BaHammam[1,2], Abdullah F. Alghannam[3], Khalid Saad Aljaloud[4], Ghadeer S. Aljuraiban[5], Mezna A. AlMarzooqi[5], Ali M. Dobia[6], Shaima A. Alothman[3], Osama Aljuhani[7], Rasha A. Alfawaz[8]

Abstract:

The Saudi Public Health Authority recently prepared a Consensus Statement regarding how much time a person should spend engaged in physical activity, sedentary behavior, and sleep to promote optimal health across all age groups. This paper describes the background literature, methodology, and modified RAND Appropriateness Method and Grading of Recommendations Assessment, Development, and Evaluation (GRADE)-ADOLOPMENT approach that guided the development process. A Leadership Group and Consensus Panels were formed, and credible existing guidelines were identified. The Panel identified clear criteria to choose the best practice guidelines for the set objectives after evaluation, based on GRADE table evidence, findings table summaries, and draft recommendations. Updating of the selected practice guidelines was performed, and the Consensus Panels separately reviewed the evidence for each behavior and decided to adopt or adapt the selected practice guideline recommendations or create *de novo* recommendations. Data related to cultural factors that may affect the studied behaviors, such as prayer times, midday napping or "Qailulah," and the holy month of Ramadan, were also reviewed. Two rounds of voting were conducted to reach a consensus for each behavior.

Keywords:

Adults, Grading of Recommendations Assessment, Development and Evaluation-ADOLOPMENT, infants, preschoolers, public health recommendations, toddlers

International studies have consistently shown that daytime movement behaviors – involving not only physical activity, but also sedentary behavior and sleep duration – are major health indicators.[1-3] These behaviors are strongly interrelated; however, several guidelines regarding factors associated with movement focus on each activity separately, which, when taken in isolation, may be insufficient for the purpose of developing and implementing recommendations needed to achieve optimal physical and mental health. A consolidated approach considers overall

How to cite this article: BaHammam AS, Alghannam AF, Aljaloud KS, Aljuraiban GS, AlMarzooqi MA, Dobia AM, *et al*. Joint consensus statement of the Saudi Public Health Authority on the recommended amount of physical activity, sedentary behavior, and sleep duration for healthy Saudis: Background, methodology, and discussion. Ann Thorac Med 2021;16:225-38.

activity across 24 h and accounts for periods of physical activity, sedentariness, and sleep.

Current evidence supports the need for regular and adequate physical activity and sleep duration as a means to longer and healthier lives and disease prevention.[1,2,4] Physical activity may decrease cardiovascular risks, improve lipid profile, control Type 2 diabetes, prevent the incidence of certain types of cancer, increase bone density, improve psychological health, cognitive function, and well-being, and reduce mortality.[3] In addition, regular physical activity may decrease inflammatory responses throughout the body. It has been established that inflammation can increase the risk of heart diseases – it accelerates aging and depression and can also lead to major neurocognitive disorders.[5] Physical activity can also improve brain health and neuroplasticity and enhance cognitive function.[6] Moreover, it may improve learning and cognitive function in children as well.[7]

On the other hand, sedentary behavior is a significant factor associated with several noncommunicable diseases and total mortality.[3,5] It is estimated that sedentary behavior is globally responsible for 9% of premature mortality, or more than 5.3 million deaths annually.[8] According to the WHO's global statistics, one in four adults is not active enough, and more than 80% of the world's adolescent population is not sufficiently physically active.[3] Several studies have linked sedentary behavior to cardiometabolic biomarkers such as increased waist circumference, triacylglycerol and HbA1c levels, and systolic blood pressure and decreased high-density lipoprotein cholesterol levels; it is also associated with increased risk of metabolic syndrome and diabetes.[9-11] A meta-analysis has also reported evidence of a significant positive association between sedentary behavior and the risk of type 2 diabetes and all-cause mortality.[12]

Insufficient sleep or irregular sleep patterns have also been linked to increased morbidity and mortality.[13-15] For instance, sleep deprivation or short sleep duration has been found to be associated with greater risks of developing heart diseases,[16] stroke,[17] type 2 diabetes,[18] hyperlipidemia,[19] high blood pressure,[20] cancer,[21] systemic inflammation,[22] and obesity.[23,24] Not getting the required amount of sleep can lead to dangerous health outcomes that may affect almost all bodily organs and systems, such as cognitive impairment, poor academic performance, hypertension, and insulin resistance, in addition to other health problems.[25] The body's immune system is negatively affected by inadequate sleep, in addition to an increase in systemic inflammation, inflammatory marker levels, and the occurrence of hormonal disturbances. Evidence suggests that insufficient sleep alters gene expression in the human blood cells and decreases circadian rhythm amplitude in gene expression. Furthermore, shorter sleep duration is associated with increased mortality, increased risk of motor vehicle accidents and industrial accidents, and deteriorating job performance.

According to national population-based data, Saudi Arabia has one of the lowest physical activity rates and the world's highest sedentary behavior rate.[26] In addition, local-level studies have demonstrated that Saudi Arabia has one of the lowest levels of nocturnal sleep duration.[27-31]

A few countries have developed specific 24-h movement guidelines regarding regular physical activity, screen time, and sleep for subjects in their early years, children and adolescents, adults, and older adults. However, there are no practice guidelines for the regulation of physical activity, sedentary behavior, and sleep over 24 h for all age groups in Saudi Arabia. Furthermore, Saudi Arabia is culturally different from Western countries, and national practice guidelines need to account for cultural factors, such as prayer times, the Ramadan month, and the habit of siesta (midday napping or "Qailulah"), that may affect behavior. This calls for the urgent need to establish specific Saudi 24-h Movement Practice Guidelines. Such guidelines will help healthcare providers prescribe the optimal amount of daily physical activity and sleep to promote a healthier lifestyle. In addition, public policy initiatives addressing worker fatigue and transportation safety are similarly hampered by the absence of evidence-based national practice guidelines that address healthy habitual physical activity and sleep duration. Local health societies and organizations have repeatedly stressed the importance of increasing physical activity, reducing sedentary behavior, and getting adequate sleep for good health; however, their message is undermined by the lack of national guidelines for physical activity, sedentary behavior, and healthy sleep duration. Therefore, health practitioners, public policymakers, and public health activities would benefit from these evidence-based guidelines and recommendations addressing the daily levels of physical activity, sedentary behavior, and sleep needed to support optimal health and functioning.

This paper describes the background literature, methodology, and modified RAND Appropriateness Method (RAM) and Grading of Recommendations Assessment, Development, and Evaluation (GRADE)-ADOLOPMENT approach that guided the development process. The recommendations are published in a concomitant paper in this issue of the Journal.[32]

Methods

Working committees and their roles

In February 2020, the Saudi Public Health Authority constituted a National Committee to develop the 24-h Movement Practice Guidelines for Saudi Arabia by integrating the relevant information on physical activity, sedentary behavior, and sleep duration. The committee comprised seven-panel members from various specialties (physical activity specialists, exercise physiologists, epidemiologists, nutrition and diet experts, sleep medicine specialists, and guideline-development methodologists) and was supported by three subcommittees (Core Panels) for each addressed topic.

The development process for each practice guideline involved two interdependent groups: a Core Panel and an Expert Panel. The Core Panel guided the Expert Panel through the voting process (in accordance with the RAM) and provided formulated recommendations to it. The Expert Panel used the data and evidence provided by the Core Panel to come to a consensus.

The Saudi Public Health Authority was responsible for communications, logistics, and final approval of guideline topics. The National Committee was responsible for supervising each guideline's development, communicating with the guideline panels, conducting the literature searches, updating the systematic review-related information, and chairing the guideline panel meetings.

The guideline core panel members were involved in:

- Prioritization of questions related to the guideline topics
- Formulation of recommendations for physical activity, sedentary behavior, and sleep duration for healthy children, adolescents, adults, and older adults during panel meetings and drafting a practice guideline manuscript for peer-reviewed publication. Summaries of the guideline development process were narrated through online presentations
- Formulation of recommendations regarding unique cultural and religious factors that may affect nighttime sleep duration, such as prayer times, daytime napping, and the Ramadan month.

Research questions defined by the Core Panel committees for physical activity, sedentary behavior, and sleep duration with respect to their duties

- Question 1: What is the dose (i.e., duration, frequency, intensity, and type) of physical activity, as measured using both objective and subjective methods, needed for optimal health?
- Question 2: What is the dose (i.e., duration, patterns [frequency, interruptions], and type) of sedentary behavior, as measured using both objective and subjective methods, needed for optimal health?
- Question 3: What is the nocturnal sleep duration needed for optimal health?

The Grading of Recommendations Assessment, Development, and Evaluation-ADOLOPMENT method

One way of developing guidelines is to use the work of previously established societies. This "GRADE-ADOLOPMENT" methodology detailed by Schünemann *et al*. in 2017[33] combines the advantages of adoption, adaptation, and *de novo* development of recommendations based on the GRADE evidence to decision frameworks.

Due to time restraints, the panel agreed to limit the selected practice guidelines to the best available guidelines that addressed the research questions. The screened guidelines were evaluated using the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument, and the practice guidelines that received the highest quality scores based on this instrument were chosen for the adaptation process. A guideline methodologist Ali M. Dobia (AMD) was also invited to be part of the guideline development team.

Moreover, each of the selected practice guidelines was updated by reviewing published systematic reviews and conducting systematic reviews of randomized controlled trials (RCTs) published after the adopted practice guidelines.

A systematic search of RCTs and non-RCTs and observational studies was performed for cultural factors that may influence nocturnal sleep duration (i.e., prayer times, naps, and the Ramadan month) as well.

Figure 1 presents the timeline and sequence of steps involved in the development of the Saudi 24-h Movement Guidelines.

Searching for guidelines and other relevant evidence

Core Panel members performed a systematic search using Medline/PubMed and Scopus to find all pertinent articles and practice guidelines published from January 2015 to April 2020 for presentation to the panel members. The keywords for each topic used in the search strategy were as follows:

- Physical activity and sedentary behavior: "physical activity;" "physical activity guidelines;" "movement guidelines;" "chronic diseases;" "review;"

Figure 1: Timeline and sequence of steps involved in the development of the Saudi 24-h Movement Guidelines for Physical Activity, Sedentary Behavior, and Sleep Duration

"systematic review;" "meta-analysis;" "randomized controlled trial;" "cardiovascular disease;" "cancer;" "hypertension;" 'diabetes;" "cognitive function;" "academic performance;" "metabolic syndrome;" "obesity;" "mortality;" "mental health;" "psychiatric health;" "immunity;" "inflammation"

- Sedentary behavior: "sedentary;" "guidelines;" "systematic review;" "meta-analysis" "obesity;" "motor development;" "psychological health;" "cognitive development;" "fitness;" "health;" "depression;" "cardiovascular*;" "cancer;" "pain;" 'diabetes;" "cognitive function;" "academic performance;" "metabolic*;" "mortality;" "mental health"
- Sleep duration: "sleep duration;" "guidelines;" "meta-analysis;" "randomized controlled trial;" "cardiovascular disease;" "cancer;" "hypertension;" "diabetes;" "cognitive function;" "memory;" "academic performance;" "metabolic syndrome;" "obesity;" "pain;" "mortality;" "metal health;" "psychiatric health;" "immunity;" "inflammation;" "job performance."

Eligibility criteria for the adopted practice guidelines

The Core Panels for each topic decided to include structured practice guidelines that were based on systematic reviews of the related research evidence. The following criteria were used to select the adopted practice guidelines: (1) published in the past 5 years; (2) addressed the research questions (covered all Population, Intervention, Comparator, and Outcome [PICO] elements); (3) followed the GRADE process; and (4) included existing and accessible GRADE tables and summaries of findings.

Information about the evidence-based methods used in the practice guidelines was obtained from the Methods sections and search strategies reported in the guidelines and grading strength of evidence.

The selected practice guidelines

For physical activity, the Core Panels adopted the UK Chief Medical Officers' Physical Activity Guidelines and supplemented them with Canadian and US Practice Guidelines to cover all age groups when needed, as these guidelines met the criteria set by the panel.[34-37] The panel used eight health indicators – adiposity, motor development, psychosocial health, cognitive development, fitness, bone and skeletal health, cardiometabolic health, and risks/harm.[3,5,6] The Saudi physical activity guidelines have been developed based on national evidence from the literature, including systematic review, RCTs, as well as recently available reports from the General Authority of Statistics, and were reviewed by the physical activity Consensus Panel. The selected guidelines and evidence were appraised by three independent reviewers based on the AGREE II instrument. Thereafter, the scores for each guideline were aggregated, and the highest scoring guideline in each age group was selected for guideline adaptation. In addition, the culture of the Saudi population, related to religion and lifestyle, was considered while adapting the selected physical activity recommendations.

For sedentary behavior, the Core Panels adopted the Australian 24-h Movement Guidelines for the Early Years (birth to 5 years), the Australian 24-h Movement Guidelines for Children (5–12 years) and Young People (13–17 years), and the UK Chief Medical Officers' Physical Activity Guidelines,[34,38,39] as these guidelines met the criteria set by the Panel. The Panel used the following health indicators: adiposity, motor development, psychosocial health, cognitive development and performance, fitness, bone and skeletal health, cardiometabolic health, cancer, pain, mortality, and risks/harm.

For sleep duration, the draft "Recommended amount of sleep for healthy adult and pediatric populations: A joint consensus statement of the American Academy of Sleep Medicine (AASM) and Sleep Research Society (SRS) and National Sleep Foundations' (NSF) "sleep time duration recommendations" best fits the criteria approved by the Sleep Duration Core Panel.[13,40,41] These were appraised based on the evidence in the GRADE tables, summaries of the tables of findings, and draft recommendations from the AASM/SRS and NSF Draft Guidelines.[33]

The Panel used the following health categories and subcategories adopted by the AASM in rounds 1 and 2 voting. These categories were general health, cardiovascular health (cardiovascular disease and hypertension), metabolic health, diabetes, obesity, mental health, mood, psychiatric health, immunologic health, immune function, inflammation, human performance, cognitive performance, driving performance, job performance, cancer (female cancers [breast, ovarian], general cancers, and colorectal cancer), pain, and mortality.[13]

Two guidelines were adopted because the AASM/SRS guidelines did not cover all the targeted age groups. Therefore, to address sleep duration in all age groups (including neonates and older adults over 65 years of age), the NSF guidelines were also used. The incorporation of these two guidelines ensured trustworthiness in the adoption and adaptation process.

The Grading of Recommendations Assessment, Development, and evaluation recommendation system

The following criteria were used to grade the evidence:
- Category A: RCTs (with narrow confidence intervals)
- Category B: Low-quality RCTs
- Category C: Nonrandomized trials and observational studies
- Category D: The Saudi Public Health Authority Expert Panel consensus judgment. This category was only used when insufficient evidence was available in the literature and the provision of a recommendation was considered important.

Although the level of recommendation confidence is a continuum, the GRADE system describes two levels of evidence: "strong" and "conditional." When feasible, we indicated the level of evidence.

A "strong" recommendation was defined as a recommendation when the panel was confident that the desirable effects of adherence to the recommendation outweighed the undesirable effects. A "conditional" recommendation was defined as a recommendation when the panel inferred that the desirable effects of adherence to the recommendation probably outweighed the undesirable effects, but the panel was not confident about the trade-offs. A conditional recommendation was indicated between brackets after the recommendation.

Preparing the draft-adopted guidelines

A qualitative exploratory descriptive study was conducted to integrate the cultural factors and local customs based on the available data. In addition, the chosen guidelines were not the only sources used. Specifically, new updates from published systematic reviews and RCTs published after the publication of the adopted practice guidelines were used to develop a thorough guideline that accounted for new updates and cultural factors [Figure 2]. The search was restricted to studies conducted in human adults and published in English. Systematic reviews of longitudinal studies and RCTs published after the publication of the adopted practice guidelines were performed [A summary of the studies is available in Supplement I].

Similar work was carried out for all studies that assessed the interaction between sleep and Ramadan, sleep and prayer times, and sleep duration and daytime naps [Supplement II].

The Core Panel members for each topic developed expository drafts of the proposed guidelines in each field (physical activity, sedentary behavior, and sleep duration). Thereafter, the organizing committee clarified

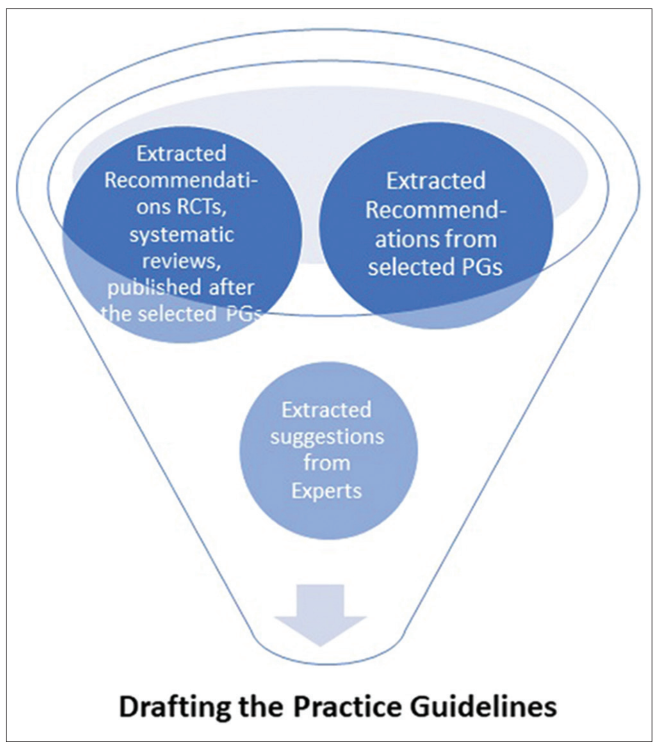

Figure 2: Integrating the recommendations extracted from the literature review, selected practice guidelines, recommendations from randomized controlled trials and systematic reviews published after the selected practice guidelines, and Expert Panel judgments

all ambiguous and incomprehensible phrases, removed redundant sentences, and ensured the overall coherence of all practice guidelines. The panel also took into consideration the traditions and culture of Saudi Arabia.

Expert Panel selection

The main selection criteria considered for selecting the expert panelists were acknowledged leadership in the panel member's specialty, absence of conflicts of interest, regional diversity (when feasible), and diversity of practice settings (academic vs. clinical practice). The experts were not chosen just because they were easily accessible or friendly.[42] The Expert Panels permitted sufficient diversity while ensuring that all members had a chance to participate.[42] This, of course, depended on the availability of specialists in each of the three addressed specialties (names of the experts are included in the Acknowledgment Section). For the physical activity Expert Panel, the panelists included specialists in exercise science, physical therapy, physical education, and exercise physiology, clinical specialists from the leading institutions in Saudi Arabia, and a research methodology expert. For the sedentary behavior Expert Panel, the panelists included specialists in sedentary behavior, exercise science, physical therapy, physical education, and exercise physiology, clinical specialists from leading institutions in Saudi Arabia, and a research methodology expert. For the sleep duration Expert Panel, the panelists included experts in sleep medicine and related specialties (family medicine, psychiatry, child development, and behavioral sleep medicine), clinical specialists from the leading institutions in Saudi Arabia and the Saudi Sleep Medicine Group, and a research methodology expert.

The modified RAND appropriateness method

Consensus on the formulated recommendation was reached using the RAM, wherein experts used the current scientific evidence in conjunction with expert opinion to reach an agreement.

The RAM utilizes crucial scientific literature, together with two turns of voting (the first of which was anonymous), to establish agreement on the suitability of approval and to avoid any ego effects or dominance that might impact the group decision-making process.

Round 1 voting

In round 1, the Expert Panel members received the recommendations via an online link and were asked to rate each recommendation's appropriateness (on a 1–5 Likert scale). They did not interact to ensure that there was no interference during voting. However, they were allowed to use the synthesized evidence provided by the Core Panel overseeing the consensus process. An Expert Information Sheet was sent to the participants in the Expert Panel for each topic (specialty) by e-mail and WhatsApp to give a brief overview of the project to all selected experts who agreed to participate in both voting rounds.

The Saudi Public Health Authority Ethics Committee approved the RAM study before its first round was initiated (approval number SCDC-IRB-A013-2020). Expert Panel member participation in the two rounds was considered as consent.

Members of each Core Panel reviewed the results of round 1 voting and the available evidence, and the Expert Panel members were provided with feedback to refine their answers. This iterative process was used to guarantee credibility.

Round 2 voting

Round 2 voting aimed to give the Expert Panel members the chance to discuss their ratings face to face over 1 day after considering their knowledge of how all the other experts had rated. Round 2 voting was conducted via a Zoom meeting and was led by an experienced moderator for each discussed topic. The moderator focused on recommendations where there was significant disagreement in the experts' ratings to find out whether there was genuine clinical disagreement about appropriateness or if there was a problem with the rating structure.[42]

Data analysis for rounds 1 and 2

The answers were aggregated, and frequencies and percentages were calculated for the answers using the online questionnaire itself before the data were tabulated with the qualitative responses as feedback for round 2.

Each indication was classified as "appropriate," "uncertain," or "inappropriate" for the procedure under review in accordance with the experts' median score and the level of disagreement among the experts. Indications with median scores in the 1–2 range were classified as inappropriate and those in the 4–5 range as appropriate; a score of 3 was classified as uncertain. Each statement that achieved 80% or higher from the summation of scores 4 and 5 on the Likert scale was considered to be in agreement. Consensus was defined as an 80% or higher agreement.

After round 1

For physical activity, one recommendation had <80% agreement in round 1, and the rest scored above 80%.

For sedentary behavior, 13 out of 16 statements achieved 80% or higher agreement. Three statements received a score <80% agreement – statement 2 received 64% agreement; statement 3 received 75% agreement; and statement 9 received 73% agreement.

For sleep duration recommendations, all statements achieved 80% or higher agreement.

After round 2

For physical activity recommendations, all statements achieved more than 80% agreement.

For sedentary behavior, all recommendations achieved more than 80% agreement.

For sleep duration recommendations, all statements achieved 90% or higher agreement.

Voting in the second round led to the establishment of the final Consensus Recommendations. After all panel members approved the phrasing and language of the final statements, they were submitted to the Saudi Public Health Authority Boards of Directors for their endorsement.

Summary of Literature

Summary of the literature published after the publication of the adopted practice guidelines

Research gaps were identified through the updates of the systematic reviews of studies published after the publication of the adopted practice guidelines.

A summary of these systematic reviews is presented in Supplement I. Twenty-six systematic reviews that assessed the impact of sleep duration on health were identified: 15 reviews in adults and 11 in children and adolescents. Thirteen RCTs assessed the effects of sleep duration on health.

The evidence extracted from the recent systematic reviews and RCTs supported the AASM/NSF recommendations; therefore, the Core Panel adopted the AASM/NSF recommendations.

Sixteen systematic reviews that assessed the impact of sedentary behavior on health were identified: Five reviews in adults, nine in children and adolescents, and two that included both children and adults.

Based on the evidence from the recent systematic reviews, the National Committee agreed to initially adopt the Australian 24-h Movement Guidelines for the Early Years (birth to 5 years), the Australian 24-h Movement Guidelines for Children (5–12 years) and Young People (13–17 years), and the UK Chief Medical Officers' Physical Activity Guidelines recommendations without major changes in the physical activity and sedentary behavior recommendations.

A few minor changes to the wording of the guidelines were made by the Saudi Consensus Panel, not to the guideline recommendations as such but more precisely to the wording of the Good Practices statements.

Although a few studies specific to the Saudi population have been published on the relationship between physical activity level and health outcomes, there is a lack of robustness in terms of both the quantity and quality of the studies. Most of the local studies were cross-sectional, and only four studies were RCTs or had a large sample size. The local studies did not address all health outcomes determined in the search methods. Only eight studies used objective measures, such as those related to the use of accelerometers or pedometers. Thus, none of the local studies could be used to modify the recommendations. Thus, a strategic national plan to develop national evidence to investigate the relationship between physical activity levels/sedentary behavior and health outcomes is strongly needed.

Summary of literature related to the interaction between Ramadan fasting, prayer times, and daytime naps on the one side and nocturnal sleep duration on the other

Daytime naps

Summary of evidence

Cross-sectional and longitudinal studies have shown that several factors other than sleep duration can affect the relationship between sleep and health outcomes, such as bedtime and rise time, self-reported sleep quality, daytime napping, and comorbid sleep disorders.[43-45] Although the current practice guidelines address sleep duration only, other factors that can affect sleep duration in Saudi culture also need to be addressed.

Napping (afternoon/midday sleep or a siesta) is a culturally driven behavior that is a common practice, especially in some Mediterranean cultures, primarily for climatic reasons.[44] In addition, daytime napping in Saudi Arabia also has a religious dimension.[46,47] Qailulah, the term used in Islamic literature to define a midday nap, is a well-established Islamic habit.[47] One Hadith by the Prophet Mohammed peace be upon him (PBUH) says, "*Take a short nap, for Devils do not take naps*" (Sahih Aljamie, Alalbani 1647). Another Hadith by the Prophet (PBUH) presents specifics about the proper timing for a nap: "*Sleeping early in the day betrays ignorance, in the middle of the day is right, and at the end of the day is stupid*" (Fath Al-Bari). Many Saudis take a daytime nap in an attempt to abide by these hadiths of the prophet. A third Hadith by the Prophet (PBUH) also points to the time of the daytime nap in Islamic culture: "*We used to offer the Jumua (Friday) prayer with the Prophet and then take the afternoon nap*" (Sahih Al-Bukhari SB 5923). Therefore, these inherent cultural factors should be considered when formulating the relevant guidelines.

The AASM consensus recommendation for adults focus on "nightly" sleep without the description of napping.[13]

Napping in adults

Summary of evidence

Studies in Saudi adults have demonstrated that daytime napping is a common practice.[30,48,49] A biphasic pattern of objective sleep tendency has been documented in healthy, normal young adults as well as the elderly.[50] Even after obtaining a normal night's sleep, a subject may experience mid-afternoon sleepiness due to circadian sleep–wake regulation mechanisms.[51]

Laboratory-based experimental studies have demonstrated several beneficial effects of napping, including improvement in cognitive function, reduced stress, enhancement of the immune system, and reduced pain.[44] On the other hand, epidemiological studies have reported that long naps are associated with increased cardiometabolic risk, mortality, and cognitive decline.[52-55] Nevertheless, not all population-based studies agree with the above findings, and some suggest that napping is not associated with an increased risk of mortality, especially in the older population.[56]

Several observational, cross-sectional studies of longevous populations from the Mediterranean region[57] and China[58,59] indicate that napping may improve survival. Two recent large-scale Chinese epidemiological studies (>18,000 participants in both studies; mean age 63 years)[58,59] with a follow-up for 3–5 years reported that, compared with shorter naps of ≤30 min and after adjusting for potential confounders, long naps (≥60 min or ≥90 min) were associated with a higher risk of incident coronary heart diseases,[58,59] hypertension,[60] type-2 diabetes,[61] and metabolic syndrome.[62]

Another study of older individuals aged 75–94 years demonstrated that, when nighttime sleep duration was accounted for, daytime napping had a protective effect in terms of mortality;[63] however, for those with a nighttime sleep duration of more than 9 h, daytime napping was associated with increased mortality risk.[63]

Nap timing

Summary of evidence

In Islamic culture, the daytime nap time is around noontime or after the Dhuhr prayer.[46,47] A study that assessed the effect of daytime napping on reaction time demonstrated that naps taken after 6 h or 18 h of rise time were more beneficial than those taken after 30 h, 42 h, or 54 h of rise time,[64] suggesting that earlier naps are beneficial, because earlier naps prevent the drop in core body temperature associated with extended wakefulness, which causes sleepiness.[64] In contrast, later naps that coincide with the circadian drop in core body temperature may necessitate a longer nap duration (e.g., >2 h) to reduce sleep pressure.[64,65] This suggests that earlier naps of shorter duration may be more beneficial than later naps of a longer duration. Moreover, a later nap time may influence nocturnal sleep.

Nap duration

Summary of evidence

Based on the currently available data [summarized in Supplement I], the ideal nap duration for healthy young adults is approximately 10–20 min.[65-70] Naps longer than 30 min may progress into slow-wave sleep, making awakening more difficult and increasing the risk of sleep inertia, usually defined as a sense of disorientation and transient reduction in cognitive performance after long naps of >30 min, which may impair alertness and performance.[71]

Napping in children

Summary of evidence

Napping is a known physiological phenomenon in children who regularly take daytime naps between 1 and 4 years of age.[72] With increasing age, daytime napping usually ceases in school-going children.[72] A longitudinal US study (sample size, 1930) that followed children from to 1997 to 2002 showed a significant association between nighttime sleep duration and obesity;[73] interestingly, the study showed that napping had no effect on the development of obesity, although it was not a substitute for sufficient nighttime sleep.[73]

However, in Saudi Arabia, studies have shown that napping continues in children in elementary school; a study in elementary schoolchildren reported that 41% of them were taking a daytime nap more than three times per week.[31,74] Napping was found to be highly prevalent in Saudi adolescents as well, with approximately 60% of participants taking daytime naps more than three times per week.[75] Another study that assessed sleep patterns among Saudi adolescents reported that 59% of the study group participants had an occasional daytime nap, and 30% reported daily napping.[76] Napping in Saudi children could be explained by going to bed late and getting up early for school, and hence not getting enough nocturnal sleep, which is compensated by daytime napping.[74] A systematic review also demonstrated that napping after the first 2 years of life correlated with reduced night sleep and hence a redistribution in 24 h sleep timing.[77]

Thus far, there is no agreement on the timing of cessation of daytime napping in children. Lack of this information makes it difficult to formulate a clear opinion about the role of napping in the development of children in different age groups and the role of daytime napping in supplementing 24-h sleep in children.[77]

A recent systematic review of napping patterns in children aged 0–12 years revealed two time points in the transition to napping cessation. In children <24 months of age, napping is common, and the cessation rate is <2.5%.[77] After this age, an evident acceleration in the cessation rate was noted, combined with an extraordinary variation in prevalence across studies and global regions.[77] Finally, after 5 years of age (equivalent to school-going age), the majority of children stopped daytime napping.[77]

However, the currently available data have major limitations, as nearly all longitudinal studies on napping have been reported from Western societies, with limited studies from our region. Therefore, the present understanding of the practice of napping among children is limited to certain geographical locations and cultures and may not necessarily be applicable to our culture. More local studies on the health effects of napping in schoolchildren are needed.

Prayer times and sleep

Summary of evidence

The sleep pattern of Saudis is significantly influenced by prayer times. Muslims are required to perform five daily obligatory prayers (As-Sala¯t) at certain times of the day. The Saudi culture is a religious culture where a good proportion of Saudis adhere to the exact prayer times. For those who strictly follow these prayer times, sleep time and pattern and light exposure are affected by these prayer times as well.[47]

Prayer times were formerly timed according to the movement of the sun. Because of the tilting of the earth, its rotation around the sun, and the various latitudes of the earth's locations, the times for the prayers are not fixed and are influenced by the season and the location.[47] Prayer times are referred to in one verse of the Qur'an as follows: "*Perform As-Sala¯t (prayer) from mid-day till the darkness of the night (i.e., the Dhuhr, Asr, Maghrib, and Isha prayers), and recite the Qur'an in the early dawn (i.e., the morning Fajr prayer)*" (17.78).

A field study of adult Omanis that objectively assessed sleep duration and pattern reported that 11% of the studied population wake up for *Fajr* prayer and then go back to sleep after prayer.[78] In addition, the same group reported the results of a field study that assessed the effect of sleep pattern in adults on inflammation and oxidative stress as reflected by the levels of the antioxidant glutathione (GSH), malondialdehyde (MDA), and C-reactive protein (CRP) in the plasma.[79] The levels of GSH, MDA, and CRP in biphasic dawn-sleepers were comparable to those in subjects with a monophasic sleep pattern; the levels were worse in subjects with a polyphasic sleep pattern, who also had more systemic inflammation.[79]

During summer, nights become shorter as days dawn earlier; hence, the *Fajr* (dawn) prayer comes at an earlier time, especially as Saudi Arabia does not apply daylight saving time.[46] Therefore, some of those who wake up for *Fajr* prayer in summer may sleep after prayer until they have to work; in other words, they split their sleep.[80] A study that assessed nocturnal sleep architecture and objective daytime sleepiness in subjects who split their sleep due to the *Fajr* prayer revealed no differences in sleep architecture or daytime sleepiness in the consolidated and split-sleep schedules when the total sleep duration was maintained.[80]

Laboratory studies indicate that having a constrained sleep period at night followed by a daytime nap has comparable recovery value to the same amount of consolidated one block-sleep taken at night.[69,81] However, most of these were short-term studies. Space simulation studies also suggest that splitting sleep into two phases does not disturb cognitive function, sleepiness, or inflammatory responses to sleep deprivation.[82,83] However, these studies are conducted under special conditions, making it difficult to extrapolate their results to the general population.

A recent study assessed hippocampal function in four groups of young adults by evaluating short-term topographical memory using the Four Mountains Test. Group 1 had 5 h of nocturnal sleep ($n = 30$), group 2 had 6.5 h of nocturnal sleep ($n = 29$), group 3 had 6.5 h of sleep split into 5 h of nocturnal time in bed and 1.5 h daytime nap ($n = 29$), while the control group 9 h of nocturnal sleep ($n = 30$).[84] Compared to the control group, Groups 1 and 2 had significantly impaired performance, while the performance of participants on the split sleep schedule (5.0 ± 1.5 h) did not significantly differ from that of controls.[84] Although the split-sleep protocol cannot be considered a replacement for adequate consolidated nocturnal sleep, this demonstrates the benefits of a long daytime nap (split sleep) in subjects who do not get enough nocturnal sleep.

A field study with junior doctors reported that adopting a split sleep protocol with napping during night shifts led to a similar amount of total sleep per 24 h as obtained by day shift doctors.[85] Nevertheless, based on the above observations, the evidence cannot be considered strong enough to draw any strong conclusions, and more studies are needed to assess the long-term effects on health outcomes.

Ramadan and sleep

Summary of evidence

Diurnal intermittent fasting during the holy month of Ramadan is the fourth pillar of Islam. This practice is anticipated to foster performers to wake-up early (at predawn) for an important meal that has a religious dimension. Ramadan is a *Hijri* month that follows the lunar system, and hence, the month occurs in a different season every 9 years, which in turn affects the duration of daytime fasting and possibly influences nocturnal sleep duration.[86,87] During Ramadan, there is a sudden shift of mealtime to the dark phase of the day. Increasing evidence shows that mealtimes interact closely with the circadian rhythm.[88] Eating during the dark phase of the day causes desynchronization between the peripheral circadian clock and the central biological clock in the suprachiasmatic nucleus.[89] The resulting misalignment increases the risk of developing cardiometabolic disorders.[90] A recent systematic review and meta-analysis of 10 observational and experimental studies that assessed the effect of meal timing on obesity and metabolic alterations in humans reported a negative impact of late meal timing on weight and metabolism.[91] Eating and staying awake for the whole night and sleeping in the daytime does not equate with getting enough nocturnal sleep.[92] Studies on shift workers who work and eat at night and sleep in the daytime have demonstrated that a considerable percentage of them develop "shift work disorder," a circadian rhythm sleep disorder characterized by excessive sleepiness, insomnia, or both.[93]

A few studies in Saudi Arabia consistently showed a significant and sudden delay in bedtime and rise time during Ramadan.[30,94-96] Interestingly, the delay in bedtime during Ramadan was also documented in non-Muslim residents of Saudi Arabia, suggesting that this delay is related to the lifestyle changes that occur during Ramadan.[30] This shift delay in the sleep/wake pattern is partially ascribed to the delay in the start of work times during the month of Ramadan in Saudi Arabia. A Saudi study that objectively assessed sleep patterns during Ramadan reported a delay in bedtime and wake times and a reduction in nocturnal sleep duration during the holy month, from 5.9 h at baseline to 4.9 h at the end of the 1st week of Ramadan and 4.8 h at the end of the 2nd week of Ramadan.[96] Another recent study demonstrated an objective reduction in nocturnal sleep duration in Saudis during Ramadan.[97] A recent meta-analysis of 24 studies demonstrated a 1 h reduction in total sleep time, with the reduction being most significant in adolescents.[98]

A study that assessed the alterations in the circadian rhythm of proximal skin temperature as a marker of core body temperature in a sample of young Saudis in an otherwise free-living unconstrained environment during Ramadan reported a delay in the acrophase of the proximal skin temperature, signifying a shift-delay in the circadian clock.[99] This finding was supplemented by two Saudi studies that demonstrated a flattening of the melatonin rhythm, suggesting that the Ramadan month could be associated with a disruption of the circadian rhythm.[95,100] Excessive eating at night and exposure to bright light, in addition to the delay in work and school times, have been proposed to cause this delay in bedtime and rise time and the reduction in nocturnal sleep.[101]

A summary of studies is shown in Supplement II.

Discussion

This paper describes the methods used to develop the Saudi 24-h Movement Practice Guidelines for all age groups with regard to physical activity, sedentary behavior, and sleep duration. These combined guidelines reflect the complementary and integrated interactions between these three behavioral aspects and shift our thinking away from individual guidelines for each behavior. This approach has been used in new guidelines in several developed countries and has been well received by stakeholders.

These guidelines will help Saudis achieve a balance of movement behaviors and encourage a shift from unhealthy behaviors (e.g., excessive screen time) to healthier behaviors (e.g., adequate age-appropriate physical activity and sleep duration), resulting in improved overall health, wellbeing, and quality of life, regardless of age. This will also help Saudis understand what a healthier day looks such as overall by shifting their focus from incorporating physical activity only into their waking hours to an understanding of what a healthy 24-h period consists of. The guidelines will also assist health professionals and policymakers as they work to support Saudis of all ages in attaining optimal health.

The current guidelines made use of recently published practice guidelines while also accounting for newly published data and adjusting for cultural factors when needed and when the relevant data were available. The methods used for developing these practice guidelines are well-established, comprehensive, and appropriate methods that are transparent and meticulous. The composition of the Core Panel members, which included specialized academics and a methodologist who guided all aspects of the development process, is a major strength of the current practice guidelines. The methodologist ensured that the Core Panels followed the GRADE system and directed the ADOLOPMENT approach. Another strength of the approach used was the diversity of the Expert Panels, which included academics, practitioners, and stakeholders related to the practice guidelines, such as general practitioners, psychiatrists, a specialist in child developmental behavior, and specialists in behavioral sleep medicine.

The current practice guidelines involved adopting previously published practice guidelines that used the GRADE approach; this method is known as the GRADE-ADOLOPMENT approach.[33,102] Based on this approach, and after reviewing the recently published evidence, the Saudi practice guidelines Expert Panels did not find sufficient changes that required altering the directions or strength of the recommendations of the adopted practice guidelines. The advantage of this approach is that it reduces time and cost; therefore, the GRADE-ADOLOPMENT approach is especially recommended when a reliable set of guidelines and related materials, such as PICOs that implement transparent processes, are available to avoid duplicates.[39]

Nevertheless, this development process is not without its challenges, as the Core Panels had to systematically review recent evidence published after the publications of the selected practice guidelines. In addition, Saudi Arabia is culturally distinct from Western societies, particularly when it comes to sleep duration, and several unique factors may affect sleep habits and hence nocturnal sleep duration. The Sleep Duration Core Panel identified the following factors that may affect sleep duration: Prayer time, including dawn (*Fajr*) prayer, the Ramadan month, and the cultural habit of taking a daytime nap.

The Core Panels discussed whether to include cross-sectional and observational studies in the updated systematic reviews; it was decided to include only recent systematic reviews and RCTs published after the publication of the adopted practice guidelines for the development of the Saudi recommendations, because even if several studies had been found, the level of evidence was not expected to have been enough to change the overall recommendation. However, for local and cultural factors that may influence behaviors, cross-sectional and observational studies were included due to a lack of high-quality and robust RCTs.

The use of online assessment for both round 1 and round 2 voting and telecommunication software availability made it easy to conduct both rounds of voting in a relatively short time.

An Arabic version of the recommendations was developed and approved by the Saudi Public Health Authority and will be promoted, which will allow the assessment of community ownership and the impact on the community.

Updating the guidelines

The National Organizing Committee recommends that these practice guidelines be reviewed and updated at least every 5 years or when significant new evidence emerges.

Strengths of the Saudi practice guidelines

The strengths of these practice guidelines include the review of evidence published after the publication of the adopted practice guidelines and cultural and religious factors being accounted for when needed. In addition, recommendations related to sleep duration during Ramadan and the interaction between nocturnal sleep and prayer times are useful for all Muslims and can serve more than 1.5 billion Muslims worldwide.

Acknowledgments

The organizing committee would like to thank all the experts who participated in voting in rounds 1 and 2 and approved the final draft of the recommendations [Supplement III].

Financial support and sponsorship

The development of this document was financially supported by the Saudi Public Health Authority (2020).

Conflicts of interest

There are no conflicts of interest.

References

1. Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: A systematic review and meta-analysis of prospective studies. Eur Heart J 2011;32:1484-92.
2. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, *et al*. Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Circulation 2007;116:1081-93.
3. World Health Organization. Global Recommendations on Physical Activity for Health. Geneva: World Health Organization; 2015.
4. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. Med Sci Sports Exerc 2009;41:998-1005.
5. Ortega E. The "bioregulatory effect of exercise" on the innate/inflammatory responses. J Physiol Biochem 2016;72:361-9.
6. Fernandes J, Arida RM, Gomez-Pinilla F. Physical exercise as an epigenetic modulator of brain plasticity and cognition. Neurosci Biobehav Rev 2017;80:443-56.
7. Hill L, Williams JH, Aucott L, Milne J, Thomson J, Greig J, *et al*. Exercising attention within the classroom. Dev Med Child Neurol 2010;52:929-34.
8. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, *et al*. Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. Lancet 2012;380:219-29.
9. Cooper AJ, Brage S, Ekelund U, Wareham NJ, Griffin SJ, Simmons RK. Association between objectively assessed sedentary time and physical activity with metabolic risk factors among people with recently diagnosed type 2 diabetes. Diabetologia 2014;57:73-82.
10. Kriska A, Delahanty L, Edelstein S, Amodei N, Chadwick J, Copeland K, *et al*. Sedentary behavior and physical activity in youth with recent onset of type 2 diabetes. Pediatrics 2013;131:e850-6.
11. Hamilton MT, Hamilton DG, Zderic TW. Sedentary behavior as a mediator of type 2 diabetes. Med Sport Sci 2014;60:11-26.

12. Proper KI, Singh AS, van Mechelen W, Chinapaw MJ. Sedentary behaviors and health outcomes among adults: A systematic review of prospective studies. Am J Prev Med 2011;40:174-82.
13. Consensus Conference Panel, Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, *et al*. Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society on the Recommended Amount of Sleep for a Healthy Adult: Methodology and Discussion. J Clin Sleep Med 2015;11:931-52.
14. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: A systematic review and meta-analysis of prospective studies. Sleep 2010;33:585-92.
15. Aurora RN, Kim JS, Crainiceanu C, O'Hearn D, Punjabi NM. Habitual sleep duration and all-cause mortality in a general community sample. Sleep 2016;39:1903-9.
16. Liu Y, Wheaton AG, Chapman DP, Cunningham TJ, Lu H, Croft JB. Prevalence of healthy sleep duration among adults – United States, 2014. MMWR Morb Mortal Wkly Rep 2016;65:137-41.
17. Li W, Wang D, Cao S, Yin X, Gong Y, Gan Y, *et al*. Sleep duration and risk of stroke events and stroke mortality: A systematic review and meta-analysis of prospective cohort studies. Int J Cardiol 2016;223:870-6.
18. Zizi F, Pandey A, Murrray-Bachmann R, Vincent M, McFarlane S, Ogedegbe G, *et al*. Race/ethnicity, sleep duration, and diabetes mellitus: Analysis of the National Health Interview Survey. Am J Med 2012;125:162-7.
19. Zhan Y, Chen R, Yu J. Sleep duration and abnormal serum lipids: The China Health and Nutrition Survey. Sleep Med 2014;15:833-9.
20. Wang Y, Mei H, Jiang YR, Sun WQ, Song YJ, Liu SJ, *et al*. Relationship between duration of sleep and hypertension in adults: A meta-analysis. J Clin Sleep Med 2015;11:1047-56.
21. Markt SC, Grotta A, Nyren O, Adami HO, Mucci LA, Valdimarsdottir UA, *et al*. Insufficient sleep and risk of prostate cancer in a large Swedish Cohort. Sleep 2015;38:1405-10.
22. Irwin MR, Olmstead R, Carroll JE. Sleep disturbance, sleep duration, and inflammation: A systematic review and meta-analysis of cohort studies and experimental sleep deprivation. Biol Psychiatry 2016;80:40-52.
23. Miller MA, Kruisbrink M, Wallace J, Ji C, Cappuccio FP. Sleep duration and incidence of obesity in infants, children, and adolescents: A systematic review and meta-analysis of prospective studies. Sleep 2018;41. doi: 10.1093/sleep/zsy018.
24. Magee L, Hale L. Longitudinal associations between sleep duration and subsequent weight gain: A systematic review. Sleep Med Rev 2012;16:231-41.
25. Chattu VK, Sakhamuri SM, Kumar R, Spence DW, BaHammam AS, Pandi-Perumal SR. Insufficient sleep syndrome: Is it time to classify it as a major noncommunicable disease? Sleep Sci 2018;11:56-64.
26. Al-Hazzaa HM. Physical inactivity in Saudi Arabia revisited: A systematic review of inactivity prevalence and perceived barriers to active living. Int J Health Sci (Qassim) 2018;12:50-64.
27. Ahmed AE, Al-Jahdali F, AlALwan A, Abuabat F, Bin Salih SA, Al-Harbi A, *et al*. Prevalence of sleep duration among Saudi adults. Saudi Med J 2017;38:276-83.
28. Al-Hazzaa HM, Musaiger AO, Abahussain NA, Al-Sobayel HI, Qahwaji DM. Prevalence of short sleep duration and its association with obesity among adolescents 15- to 19-year olds: A cross-sectional study from three major cities in Saudi Arabia. Ann Thorac Med 2012;7:133-9.
29. Althakafi KA, Alrashed AA, Aljammaz KI, Abdulwahab IJ, Hamza R, Hamad AF, *et al*. Prevalence of short sleep duration and effect of co-morbid medical conditions – A cross-sectional study in Saudi Arabia. J Family Med Prim Care 2019;8:3334-9.
30. BaHammam A. Assessment of sleep patterns, daytime sleepiness, and chronotype during Ramadan in fasting and nonfasting individuals. Saudi Med J 2005;26:616-22.
31. BaHammam A, Bin Saeed A, Al-Faris E, Shaikh S. Sleep duration and its correlates in a sample of Saudi elementary school children. Singapore Med J 2006;47:875-81.
32. Alfawaz RA, Aljuraiban GS, AlMarzooqi MA, Alghannam AF, BaHammam AS, Dobia AM, *et al*. The recommended amount of physical activity, sedentary behavior, and sleep duration for healthy Saudis: A joint consensus statement of the Saudi Center for Disease Prevention and Control. Ann Thorac Med 2021;16:239-44.
33. Schünemann HJ, Wiercioch W, Brozek J, Etxeandia-Ikobaltzeta I, Mustafa RA, Manja V, *et al*. GRADE Evidence to Decision (EtD) frameworks for adoption, adaptation, and *de novo* development of trustworthy recommendations: GRADE-ADOLOPMENT. J Clin Epidemiol 2017;81:101-10.
34. Foster C, Reilly JJ, Russell J, Murphy M, Skelton DA, Cooper AJ, *et al*. UK Chief Medical Officers' Physical Activity Guidelines. Department of Health and Social Care; 2019.
35. Tremblay MS, Carson V, Chaput JP, Connor Gorber S, Dinh T, Duggan M, *et al*. Canadian 24-hour movement guidelines for children and youth: An integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab 2016;41:S311-27.
36. Tremblay MS, Chaput JP, Adamo KB, Aubert S, Barnes JD, Choquette L, *et al*. Canadian 24-hour movement guidelines for the early years (0-4 years): An integration of physical activity, sedentary behaviour, and sleep. BMC Public Health 2017;17:874.
37. U.S. Department of Health and Human Services. Physical Activity Guidelines for Americans. 2nd ed. Washington, DC: USA; 2018. Available from: https://health.gov/sites/default/files/2019-09/Physical_Activity_Guidelines_2nd_edition.pdf. [Last accessed on 2020 Feb 26].
38. Okely AD, Ghersi D, Hesketh KD, Santos R, Loughran SP, Cliff DP, *et al*. A collaborative approach to adopting/adapting guidelines - The Australian 24-hour movement guidelines for the early years (birth to 5 years): An integration of physical activity, sedentary behavior, and sleep. BMC Public Health 2017;17:869.
39. Okely A, Salmon J, Vella S, Cliff D, Timperio A, Tremblay M, *et al*. A Systematic Review to inform the Australian Sedentary Behaviour Guidelines for Children and Young People. Report Prepared for the Australian Government Department of Health; 2012.
40. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, *et al*. Recommended amount of sleep for pediatric populations: A Consensus Statement of the American Academy of Sleep Medicine. J Clin Sleep Med 2016;12:785-6.
41. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, *et al*. Consensus Statement of the American Academy of Sleep Medicine on the Recommended Amount of Sleep for Healthy Children: Methodology and Discussion. J Clin Sleep Med 2016;12:1549-61.
42. Fitch K, Bernstein SJ, Aguilar MD, Burnand B, LaCalle JR. The RAND/UCLA Appropriateness Method User's Manual. Santa Monica, CA: Rand Corp; 2001. p. 1-117.
43. Buysse DJ. Sleep health: Can we define it? Does it matter? Sleep 2014;37:9-17.
44. Faraut B, Andrillon T, Vecchierini MF, Leger D. Napping: A public health issue. From epidemiological to laboratory studies. Sleep Med Rev 2017;35:85-100.
45. Czeisler CA. Duration, timing and quality of sleep are each vital for health, performance and safety. Sleep Health 2015;1:5-8.
46. Bahammam AS. Sleep from an Islamic perspective. Ann Thorac Med 2011;6:187-92.
47. Bahammam AS, Gozal D. Qur'anic insights into sleep. Nat Sci Sleep 2012;4:81-7.
48. Wali SO, Krayem AB, Samman YS, Mirdad S, Alshimemeri AA, Almobaireek A. Sleep disorders in Saudi health care workers. Ann Saudi Med 1999;19:406-9.
49. Al-Tannir M, Kobrosly SY, Al-Badr AH, Salloum NA, Altannir YM. Characterizing sleeping habits and disturbances

among Saudi adults. Saudi Med J 2016;37:1372-80.
50. Richardson GS, Carskadon MA, Orav EJ, Dement WC. Circadian variation of sleep tendency in elderly and young adult subjects. Sleep 1982;5 Suppl 2:S82-94.
51. Lavie P. Ultrashort sleep-waking schedule. III. 'Gates' and 'forbidden zones' for sleep. Electroencephalogr Clin Neurophysiol 1986;63:414-25.
52. Chen GC, Liu MM, Chen LH, Xu JY, Hidayat K, Li FR, *et al*. Daytime napping and risk of type 2 diabetes: A meta-analysis of prospective studies. Sleep Breath 2018;22:815-24.
53. Cheungpasitporn W, Thongprayoon C, Srivali N, Vijayvargiya P, Andersen CA, Kittanamongkolchai W, *et al*. The effects of napping on the risk of hypertension: A systematic review and meta-analysis. J Evid Based Med 2016;9:205-12.
54. Guo VY, Cao B, Wong CK, Yu EY. The association between daytime napping and risk of diabetes: A systematic review and meta-analysis of observational studies. Sleep Med 2017;37:105-12.
55. Papandreou C, Díaz-López A, Babio N, Martínez-González MA, Bulló M, Corella D, *et al*. Long daytime napping is associated with increased adiposity and type 2 diabetes in an elderly population with metabolic syndrome. J Clin Med. 2019;8:1053. doi: 10.3390/jcm8071053.
56. Leng Y, Wainwright NW, Cappuccio FP, Surtees PG, Hayat S, Luben R, *et al*. Daytime napping and the risk of all-cause and cause-specific mortality: A 13-year follow-up of a British population. Am J Epidemiol 2014;179:1115-24.
57. Naska A, Oikonomou E, Trichopoulou A, Psaltopoulou T, Trichopoulos D. Siesta in healthy adults and coronary mortality in the general population. Arch Intern Med 2007;167:296-301.
58. Liu X, Zhang Q, Shang X. Meta-analysis of self-reported daytime napping and risk of cardiovascular or all-cause mortality. Med Sci Monit 2015;21:1269-75.
59. Yang L, Yang H, He M, Pan A, Li X, Min X, *et al*. Longer sleep duration and midday napping are associated with a higher risk of CHD incidence in middle-aged and older Chinese: The Dongfeng-Tongji cohort study. Sleep 2016;39:645-52.
60. Cao Z, Shen L, Wu J, Yang H, Fang W, Chen W, *et al*. The effects of midday nap duration on the risk of hypertension in a middle-aged and older Chinese population: A preliminary evidence from the Tongji-Dongfeng Cohort Study, China. J Hypertens 2014;32:1993-8.
61. Fang W, Li Z, Wu L, Cao Z, Liang Y, Yang H, *et al*. Longer habitual afternoon napping is associated with a higher risk for impaired fasting plasma glucose and diabetes mellitus in older adults: Results from the Dongfeng-Tongji cohort of retired workers. Sleep Med 2013;14:950-4.
62. Wu J, Xu G, Shen L, Zhang Y, Song L, Yang S, *et al*. Daily sleep duration and risk of metabolic syndrome among middle-aged and older Chinese adults: Cross-sectional evidence from the Dongfeng-Tongji cohort study. BMC Public Health 2015;15:178.
63. Cohen-Mansfield J, Perach R. Sleep duration, nap habits, and mortality in older persons. Sleep 2012;35:1003-9.
64. Dinges DF, Orne MT, Whitehouse WG, Orne EC. Temporal placement of a nap for alertness: Contributions of circadian phase and prior wakefulness. Sleep 1987;10:313-29.
65. Milner CE, Cote KA. Benefits of napping in healthy adults: Impact of nap length, time of day, age, and experience with napping. J Sleep Res 2009;18:272-81.
66. Brooks A, Lack L. A brief afternoon nap following nocturnal sleep restriction: Which nap duration is most recuperative? Sleep 2006;29:831-40.
67. Hayashi M, Hori T. The effects of a 20-min nap before post-lunch dip. Psychiatry Clin Neurosci 1998;52:203-4.
68. Hayashi M, Watanabe M, Hori T. The effects of a 20 min nap in the mid-afternoon on mood, performance and EEG activity. Clin Neurophysiol 1999;110:272-9.
69. Tietzel AJ, Lack LC. The short-term benefits of brief and long naps following nocturnal sleep restriction. Sleep 2001;24:293-300.
70. Tietzel AJ, Lack LC. The recuperative value of brief and ultra-brief naps on alertness and cognitive performance. J Sleep Res 2002;11:213-8.
71. Tassi P, Muzet A. Sleep inertia. Sleep Med Rev 2000;4:341-53.
72. Chaput JP, Dutil C, Sampasa-Kanyinga H. Sleeping hours: What is the ideal number and how does age impact this? Nat Sci Sleep 2018;10:421-30.
73. Bell JF, Zimmerman FJ. Shortened nighttime sleep duration in early life and subsequent childhood obesity. Arch Pediatr Adolesc Med 2010;164:840-5.
74. BaHammam A, AlFaris E, Shaikh S, Bin Saeed A. Prevalence of sleep problems and habits in a sample of Saudi primary school children. Ann Saudi Med 2006;26:7-13.
75. Nasim M, Saade M, AlBuhairan F. Sleep deprivation: Prevalence and associated factors among adolescents in Saudi Arabia. Sleep Med 2019;53:165-71.
76. Merdad RA, Merdad LA, Nassif RA, El-Derwi D, Wali SO. Sleep habits in adolescents of Saudi Arabia; distinct patterns and extreme sleep schedules. Sleep Med 2014;15:1370-8.
77. Thorpe K, Staton S, Sawyer E, Pattinson C, Haden C, Smith S. Napping, development and health from 0 to 5 years: A systematic review. Arch Dis Child 2015;100:615-22.
78. Al-Abri MA, Al Lawati I, Zadjali F, Ganguly S. Sleep patterns and quality in Omani adults. Nat Sci Sleep 2020;12:231-7.
79. Al-Lawati IM. Sleep Patterns and Cardiometabolic Risk in Omani Adults [PhD Thesis]. Muscat, Oman: Sultan Qaboos University; 2017.
80. Bahammam AS, Sharif MM, Spence DW, Pandi-Perumal SR. Sleep architecture of consolidated and split sleep due to the dawn (Fajr) prayer among Muslims and its impact on daytime sleepiness. Ann Thorac Med 2012;7:36-41.
81. Faraut B, Boudjeltia KZ, Dyzma M, Rousseau A, David E, Stenuit P, *et al*. Benefits of napping and an extended duration of recovery sleep on alertness and immune cells after acute sleep restriction. Brain Behav Immun 2011;25:16-24.
82. Mollicone DJ, Van Dongen HP, Rogers NL, Dinges DF. Response surface mapping of neurobehavioral performance: Testing the feasibility of split sleep schedules for space operations. Acta Astronaut 2008;63:833-40.
83. Shearer WT, Reuben JM, Mullington JM, Price NJ, Lee BN, Smith EO, *et al*. Soluble TNF-alpha receptor 1 and IL-6 plasma levels in humans subjected to the sleep deprivation model of spaceflight. J Allergy Clin Immunol 2001;107:165-70.
84. Cousins JN, Van Rijn E, Ong JL, Chee MWL. A split sleep schedule rescues short-term topographical memory after multiple nights of sleep restriction. Sleep 2019;42:zsz018. doi: 10.1093/sleep/zsz018.
85. Wang P, Ren FM, Lin Y, Su FX, Jia WH, Su XF, *et al*. Night-shift work, sleep duration, daytime napping, and breast cancer risk. Sleep Med 2015;16:462-8.
86. Qasrawi SO, Pandi-Perumal SR, BaHammam AS. The effect of intermittent fasting during Ramadan on sleep, sleepiness, cognitive function, and circadian rhythm. Sleep Breath 2017;21:577-86.
87. Almeneessier AS, Pandi-Perumal SR, BaHammam AS. Intermittent fasting, insufficient sleep, and circadian rhythm: Interaction and effects on the cardiometabolic system. Curr Sleep Med Rep 2018;4:179-95.
88. Kessler K, Pivovarova-Ramich O. Meal timing, aging, and metabolic health. Sleep 2019;42:zsz018. doi: 10.1093/sleep/zsz018.
89. Allison KC, Goel N. Timing of eating in adults across the weight spectrum: Metabolic factors and potential circadian mechanisms. Physiol Behav 2018;192:158-66.
90. St-Onge MP, Ard J, Baskin ML, Chiuve SE, Johnson HM, Kris-Etherton P, *et al*. Meal timing and frequency: Implications for cardiovascular disease prevention: A scientific statement from the American Heart Association. Circulation 2017;135:e96-121.

91. Beccuti G, Monagheddu C, Evangelista A, Ciccone G, Broglio F, Soldati L, *et al*. Timing of food intake: Sounding the alarm about metabolic impairments? A systematic review. Pharmacol Res 2017;125:132-41.
92. BaHammam AS, Almeneessier AS. Recent evidence on the impact of Ramadan diurnal intermittent fasting, mealtime, and circadian rhythm on cardiometabolic risk: A review. Front Nutr 2020;7:28.
93. Wickwire EM, Geiger-Brown J, Scharf SM, Drake CL. Shift work and shift work sleep disorder: Clinical and organizational perspectives. Chest 2017;151:1156-72.
94. Bahammam AS. Sleep pattern, daytime sleepiness, and eating habits during the month of Ramadan. Sleep Hypn 2003;5:165-74.
95. BaHammam A. Effect of fasting during Ramadan on sleep architecture, daytime sleepiness and sleep pattern. Sleep Biol Rhythm 2004;2:135-43.
96. Bahammam AS, Alaseem AM, Alzakri AA, Sharif MM. The effects of Ramadan fasting on sleep patterns and daytime sleepiness: An objective assessment. J Res Med Sci 2013;18:127-31.
97. Alghamdi AS, Alghamdi KA, Jenkins RO, Alghamdi MN, Haris PI. Impact of Ramadan on physical activity and sleeping patterns in individuals with type 2 diabetes: The first study using fitbit device. Diabetes Ther 2020;11:1331-46.
98. Faris MA, Jahrami HA, Alhayki FA, Alkhawaja NA, Ali AM, Aljeeb SH, *et al*. Effect of diurnal fasting on sleep during Ramadan: A systematic review and meta-analysis. Sleep Breath 2020;24:771-82.
99. BaHammam A, Alrajeh M, Albabtain M, Bahammam S, Sharif M. Circadian pattern of sleep, energy expenditure, and body temperature of young healthy men during the intermittent fasting of Ramadan. Appetite 2010;54:426-9.
100. Almeneessier AS, Bahammam AS, Sharif MM, Bahammam SA, Nashwan SZ, Pandi Perumal SR, *et al*. The influence of intermittent fasting on the circadian pattern of melatonin while controlling for caloric intake, energy expenditure, light exposure, and sleep schedules: A preliminary report. Ann Thorac Med 2017;12:183-90.
101. Almeneessier AS, BaHammam AS. How does diurnal intermittent fasting impact sleep, daytime sleepiness, and markers of the biological clock? Current insights. Nat Sci Sleep 2018;10:439-52.
102. Alonso-Coello P, Oxman AD, Moberg J, Brignardello-Petersen R, Akl EA, Davoli M, *et al*. GRADE Evidence to Decision (EtD) frameworks: A systematic and transparent approach to making well informed healthcare choices. 2: Clinical practice guidelines. BMJ 2016;353:i2089.

Supplement I

Table 1: A summary of systematic reviews and meta-analyses that assessed the relationship between sedentary behavior and health outcomes[a]

Study	Design and study population	Study details
In children (published after March 2017)		
Wiersma *et al.*[1]	A meta-analysis of 48 studies were included that assessed the association between total PA, SB, or different PA intensities and adiposity in children aged 2-7 years	No significant associations were SB with BMI or waist circumference
Sousa-Sá *et al.*[2]	A systematic review included 26 studies were included, involving 24,448 children and adolescents aged 0-18 years, from 12 different countries. The review assessed the associations between PA, SB, and/or adiposity and retinal microvasculature	Vessel width parameters were negatively associated with higher adiposity, lack of PA, and high levels of SB
Sampasa-Kanyinga *et al.*[3]	A systematic review included 13 studies, involving 115,540 children and adolescents from 12 countries which assessed the relationship between the combinations of PA, SB, and sleep duration to depressive symptoms and other mental health indicators among children and adolescents (5-17 years)	There were positive associations between meeting PA, SB, and sleep Canadian 24-h movement recommendations and better mental health indicators when compared with meeting none of the recommendations. A dose-response gradient between an increasing number of recommendations met and better mental health indicators was observed. Results should be interpreted with caution because the quality of evidence reviewed was "very low" according to the GRADE framework
Königstein *et al.*[4]	A systematic review aimed to assess the associations of SB with large artery structure and function in pediatric populations found 8 studies to complete a qualitative analysis	There was small body of evidence (7 cross-sectional studies) that shows no association of SB with large artery structure and function
Jones *et al.*[5]	A meta-analysis of 112 studies that assessed the effectiveness of school-based interventions in increasing PA and/or reducing SB in children aged 5-11 years	Assessment of studies using a whole-day accelerometer measure for SB showed a large but nonsignificant effect for SB (effect size=1.15; 95% CI: −1.03-3.33); the meta-analyses demonstrated low precision, considerable inconsistency, and high heterogeneity
Van de Kolk *et al.*[6]	A systematic review aimed to evaluate the effectiveness of parental involvement in childcare-based interventions on the children's weight status and behavioral outcomes found 22 studies to review	Intervention group showed positive results in 61.1% of the studies on weight status, 73.3% on PA, 88.9% on SB, and all on nutrition-related behavior
Smith *et al.*[7]	A systematic review aimed to assess the associations between muscular fitness (i.e., strength/power, local muscular endurance) and SB in children and adolescents found 25 studies to review	For both muscular fitness components (strength/power, local muscular endurance), associations with SB were inconsistent irrespective of measurement method (subjective or objective)
Parajára *et al.*[8]	A systematic review aimed to assess the association between SB outcomes in adolescents (10-19 years) and neighborhood characteristics found 16 studies to review	The evidence has great variability in the SB cutoff points and methodology used for evaluating SB and neighborhood characteristics among studies Higher levels of SB was associated with insecurity during daytime hours, crime incidence, physical and social disorders, a higher neighborhood socioeconomic level, and time spent with peers Lower levels of SB was associated with traffic, availability of a favorable environment for physical activity, and higher residential density
Bedard *et al.*[9]	A meta-analysis of 20 studies, involving 842 students, assessed the impact of active classrooms compared to traditional sedentary classrooms on educational outcomes of school-aged children	Pooled results show that there is a small positive effect of active classrooms compared with traditional, sedentary classrooms (SMD=0.28, 95% CI: 0.09-0.47) on academic performance

Contd...

Table 1: Contd...

Study	Design and study population	Study details
In adults and children		
Zabatiero *et al.*[10]	A meta-analysis of 9 RCT studies that assessed the effectiveness of interventions to reduce SB among people with overweight or obesity, involving 1859 participants	Pooled results indicate that intervention decrease SB compared to the control group: −0.33 [−0.59-−0.08] overall and−0.53 [−0.95-−0.11] in adults Subgroup analyses indicated Only interventions that included active components reduced time spent in SB (−0.54 [−0.88-−0.20]) and increased time spent in MVPA (1.29 [0.02-2.56]) Interventions only reduced BMI in studies of children (−0.09 [−0.18-−0.00]) and in those with no active component (−0.09 [−0.18-−0.01])
Stanczykiewicz *et al.*[11]	A meta-analysis of 17 studies that assessed the relationships SB and anxiety, involving 27,443 participants	Pooled results indicated that overall average effects were small: Higher levels of symptoms of anxiety were associated with higher levels of SB (weighted r=0 .093, 95% CI [0.055-0.130], P<0.001). Moderator analyses indicated that trends for stronger effects were observed among adults, compared to children/adolescents (P=0.085)
In adults (published after January 2019)		
Yan *et al.*[12]	A meta-analysis of 18 cohort studies, involving 250,063 participants and 2269 patients with dementia	Pooled result showed that SB was significantly associated with increased risk of dementia (RR=1.30; 95% CI: 1.12-1.51)
Peachey *et al.*[13]	A meta-analysis of 35 intervention studies aimed to reduce SB, involving 5983 participants	The pooled effect indicated a significant reduction in daily sitting time of−30.37 min/day (95% CI−40.86-−19.89) favoring the intervention group. Reductions in sitting time were similar between workplace (−29.96 min/day; 95% CI−44.05-−15.87) and other settings (−30.47 min/day; 95% CI−44.68-−16.26), which included community, domestic, and recreational environments. Environmental interventions had the largest reduction in daily sitting time (−40.59 min/day; 95% CI−61.65-−19.53), followed by multicomponent (−35.53 min/day; 95% CI−57.27-−13.79) and behavioral (−23.87 min/day; 95% CI−37.24-−10.49) interventions
Olanrewaju *et al.*[14]	A systematic review of 18 studies involving 40,228 participants that assessed the association of SB with cognitive function in older adults without dementia	Due to considerable methodological, participant, outcome, and exposure heterogeneity, a meta-analysis could not be conducted; thus, a conclusion of the status of SB association with cognitive function cannot be drawn
Lutz *et al.*[15]	A systematic review aimed to perform a critical appraisal and synthesis of health economic evaluations of interventions aiming to increase PA and/or decrease SB at the workplace found 18 studies to review	From these 18 studies, only 3 studies measured SB and all found positive effects. However, effects were small and their relevance is questionable. No particular intervention type was found to be more effective Health economic evaluations were heterogeneous regarding methodological approaches, the selection of cost categories was inconsistent, and effects on costs were subject to substantial uncertainty. Thus, the economic evidence for worksite PA/SB interventions remains unclear
Landais *et al.*[16]	A systematic review aimed to summarize studies on microenvironmental choice architecture interventions that encouraged PA or discouraged SB in adults found 88 studies to review	Only 2 studies targeted SB; thus, no conclusion can be formed

[a]Five reviews in adults, nine in children and adolescents, and two included both children and adults. SB=Sedentary behavior, PA=Physical activity, GRADE=Grading of recommendations assessment, development and evaluation, CI=Confidence interval, SMD=Standardized mean differences, RR=Relative risk, RCT=Randomized controlled trials, BMI=Body mass index

Table 2: A summary of systematic reviews and meta-analyses that assessed the relationship between sleep duration and health outcomes (after 2015)

Author	Design and study population	Study details
Cancer/mortality		
Stone *et al.*[17]	A meta-analysis of 32 studies were included representing over 73,000 deaths in cancer survivors	Pooled hazards ratios for short and long sleep duration (≥9-10 h) for all cancer-specific mortality were 1.03 (95% CI 1.00-1.06) and 1.09 (95% CI 1.04-1.13) (≤5-6 h), respectively These associations were maintained when stratified by sex and sampling frame
Chen *et al.*[18]	A meta-analysis of 65 studies from 25 articles, involving 1,550,524 participants and 86,201 cancer cases	The categorical meta-analysis revealed that neither short (≤6 h) nor long sleep duration (≥ was associated with increased cancer risk Subgroup analysis revealed that short sleep duration was associated with cancer risk among Asians (OR=1.36; 95% CI: 1.02-1.80) and long sleep duration significantly increased the risk of colorectal cancer (OR=1.21; 95% CI: 1.08-1.34)
da Silva *et al.*[19]	A meta-analysis of 27 cohort studies of >70,000 elderly individuals and followed up from 3.4 to 35 years	Long (>10 h) and short sleep (<6 h) duration was associated with increased all-cause mortality (RR=1.33 and RR=1.07, respectively), compared with the reference category For cardiovascular mortality, the pooled relative risks were 1.43 for long sleep and 1.18 for short sleep Daytime napping ≥30 min was associated with risk of all-cause mortality (RR=1.27), but longer sleep duration (≥2.0 h) was not
Lu *et al.*[20]	A meta-analysis of 10 studies including 415,865 participants	A J-shaped nonlinear trend was found between sleep duration and breast cancer incidence (*P*-nonlinear=0.012); compared with the reference hours (6 h or 7 h), with increasing sleep hours, the risk of breast cancer increased (*P*-trend=0.028)
Jike *et al.*[21]	A meta-analysis of 137 prospective cohort studies, including 5,134,036 participants	Long sleep was significantly associated with mortality (RR, 1.39; 95% CI, 1.31-1.47), incident type 2 diabetes (1.26, 1.11-1.43), cardiovascular disease (1.25, 1.14-1.37), stroke (1.46, 1.26-1.69), coronary heart disease (1.24, 1.13-1.37), and obesity (1.08, 1.02-1.15). Long sleep was not significantly related to incident hypertension (1.01, 0.95-1.07)
Itani *et al.*[22]	A meta-analysis of 153 studies comprising 5,172,710 participants	Short sleep was significantly associated with the mortality outcome (RR, 1.12; 95% CI, 1.08-1.16). Similar significant results were observed in Type 2 diabetes (1.37, 1.22-1.53), hypertension (1.17, 1.09-1.26), cardiovascular diseases (1.16, 1.10-1.23), coronary heart diseases (1.26, 1.15-1.38), and obesity (1.38, 1.25-1.53)
Yin *et al.*[23]	A meta-analysis of 67 articles with 141 independent reports	U-shaped associations were indicated between sleep duration and risk of all outcomes, with the lowest risk observed for short sleep duration (<7 h sleep duration per day), which was varied little by sex For all-cause mortality, the RR was 1.06 (95% CI, 1.04-1.07) per 1 h reduction below 7 h; when sleep duration was>7 h per day, the pooled RR was 1.13 (95% CI, 1.11-1.15) per 1 h increment For total cardiovascular disease, the pooled RR was 1.06 (95% CI, 1.03-1.08) per 1 h reduction and 1.12 (95% CI, 1.08-1.16) per 1 h increment of sleep duration For coronary heart disease, the pooled RR was 1.07 (95% CI, 1.03-1.12) per 1 h reduction and 1.05 (95% CI, 1.00-1.10) per 1 h increment of sleep duration For stroke, the pooled RR was 1.05 (95% CI, 1.01-1.09) per 1 h reduction and 1.18 (95% CI, 1.14-1.21) per 1 h increment of sleep duration
Kwok *et al.*[24]	A meta-analysis of 74 studies including 3340 684 participants with 242,240 deaths among 2,564,029 participants Participants who reported death events were reviewed	Self-reported duration of sleep>8 h was associated with a moderate increased risk of all-cause mortality, with risk ratio, 1.14 (1.05-1.25) for 9 h, risk ratio, 1.30 (1.19-1.42) for 10 h, and risk ratio, 1.47 (1.33-1.64) for 11 h No significant difference was identified for periods of self-reported sleep <7 h
Other meta-analyses in adults		
Xi *et al.*[25]	A meta-analysis of 12 studies involving 18,720 participants with metabolic syndrome and 70,833 controls	Short sleep duration was associated with increased risk of MS (OR=1.27, 1.09-1.47)

Contd...

Table 2: Contd...

Author	Design and study population	Study details
Kruisbrink *et al.*[26]	A meta-analysis of 13 studies that assessed the longitudinal relationships between sleep disturbances (of quantity and quality) and dyslipidemia in the general population	Short sleep (≤5-7 h) was associated with a risk of 1.01 (95% CI 0.93-1.10) of developing dyslipidemia; long sleep (≥9 h) was associated with a risk of 0.98 (95% CI 0.87-1.10) for dyslipidemia
Irwin *et al.*[27]	A meta-analysis of studies (>50,000 participants) that assessed the effects of sleep disturbance, sleep duration, and inflammation in adult humans	Long sleep duration (>8 h), but not short sleep duration (<8 h), are associated with increases in markers of systemic inflammation
Anothaisintawee *et al.*[28]	A meta-analysis of 36 studies (1,061,555 participants) on sleep duration and diabetes type 2	Pooled RRs of sleeping ≤5 h and 6 h were, respectively, 1.48 (1.25,1.76), and 1.18 (1.10,1.26)
Wang *et al.*[29]	A meta-analysis of 17 articles involving 17,841 incident cases of CAD among 517,440 participants	A U-shaped relationship was detected between sleep duration and risk of coronary heart disease, with the lowest risk at 7-8 h/day The combined RR of CAD was 1.11 (1.05-1.16) for a reduction of 1 h of sleep (compared to 7 h/day)
He *et al.*[30]	A meta-analysis of 16 prospective studies, involving 528,653 participants with 12,193 stroke events	The lowest risk observed with sleeping for 7 h/day Short sleep durations were only significantly associated with nonfatal stroke A slightly decreased risk of ischemic stroke among short sleepers Long sleepers had a higher predicted risk of total stroke than short sleepers (the pooled RR: 4 h: 1.17 [0.99-1.38]; 5 h: 1.17 [1.00-1.37]; 6 h: 1.10 [1.00-1.21]; 8 h: 1.17 [1.07-1.28]; 9 h: 1.45 [1.23-1.70]; 10 h: 1.64 [1.4-1.92])
Li *et al.*[31]	A meta-analysis of 11 articles with 16 independent reports (sleep duration and stroke)	The pooled RR for stroke events was 1.07 (1.02-1.12) for each 1 h shorter sleep duration (<7 h/day) and 1.17 (1.14-1.20) for each 1 h increase of sleep duration (>7 h/day) The pooled RR for stroke mortality was 1.17 (95% CI 1.13-1.20) per 1 h increase of sleep duration
Lo *et al.*[32]	A total of 35 independent samples (n=97,264) from 11 cross-sectional and seven prospective cohort studies of adults >55 years were included Sleep durations ranged from 5 to 9 h across studies, 7 h, 8 h, and 7-8 h were most commonly used	Self-reported short and long sleep increased the odds for poor cognitive function by 1.40 (CI=1.27-1.56) and 1.58 times (CI=1.43-1.74), respectively
Meta-analyses in children		
Shan *et al.*[33]	A meta-analysis of 33 studies (including 3 randomized controlled trials and 30 observational studies)	A U-shaped dose-response relationship was observed between sleep duration and risk of type 2 diabetes, with the lowest risk observed at a sleep duration category of 7-8 h/day The pooled relative risks for type 2 diabetes were 1.09 (95% CI 1.04-1.15) for each 1 h shorter sleep duration <7 h
Felső *et al.*[34]	A systematic review 33 studies (including 3 randomized controlled trials and 30 observational studies Most of the studies were conducted in America Objective assessment of sleep duration via wrist worn accelerometer in 9 and waist worn accelerometer in 14 studies	Negative relationship between sleep time and different measures of adiposity
Krietsch *et al.*[35]	A systematic review of 86 studies of youth (0-18 years), which investigated the relationship between sleep and dietary intake, altered eating behavior, physical/sedentary activity, or hormones regulating hunger/satiety	No cross-sectional association between sleep duration and caloric intake and shorter or later sleep associating with greater sedentary or screen time

Contd...

Table 2: Contd...

Author	Design and study population	Study details
Chiu *et al.*[36]	This is a systematic review of 13 reports that included a total of 598,281 participants for a systematic review, and 12 reports were further used for a dose-response meta-analysis that assessed the association between sleep duration and suicidality in adolescents	Strong curvilinear dose-response associations were obtained for both suicidal ideation and attempts, with the lowest suicidal ideation and attempt risks at sleep durations of 8 h and 8-9 h/day (all *P*-nonlinearity <0.001) A linear dose-response relationship between sleep duration and suicide plans (pooled OR=0.89, 95% CI=0.88-0.90) was obtained, indicating that the risk of suicide plans statistically decreased by 11% for every 1 h increase in sleep duration
Short *et al.*[37]	A meta-analysis of 19 studies that objectively assessed the relationship between sleep duration and cognitive function in children aged 5-13 years	A significant effect (*r*=0.06) was found between sleep duration and cognition, suggesting that longer sleep durations were associated with better cognitive functioning
Miller *et al.*[38]	A meta-analysis of 52 studies that assessed the prospective relationship between sleep and obesity in a pediatric population	Short sleep was associated with a greater risk of developing overweight or obesity in infancy (RR: 1.40; 95% CI 1.19-1.65; *P*<0.001), early childhood (RR: 1.57; 1.40-1.76; *P*<0.001), middle childhood (RR: 2.23; 2.18-2.27; *P*<0.001), and adolescence (RR: 1.30; 1.11-1.53; *P*<0.002)
Anothaisintawee *et al.*[28]	A meta-analysis of 12 prospective cohort studies that estimated the associations between sleep duration and obesity/BMI in children	Short sleep duration was significantly associated with obesity (RR: 1.45; 95% CI: 1.14-1.85).
Chaput *et al.*[39]	A systematic review of 69 studies (included 148,524 unique participants from 23 countries) that assessed the association sleep duration and health indicators in children (0-4 years)	Despite important limitations in the available evidence, longer sleep duration was generally associated with better body composition, emotional regulation, and growth in children aged 0-4 years Shorter sleep duration was also associated with longer screen time use and more injuries
Wu *et al.*[40]	A meta-analysis of 13 articles were included, involving 35,540 children and adolescents from around the world	The OR in short sleepers for obesity of the pooled was 1.71 (1.36-2.14)
Zhang *et al.*[41]	His systematic review aimed to summarize correlates of sleep duration in children under 5 years of age One-hundred and sixteen studies, representing 329,166 children, met the inclusion criteria, with a high risk of bias in 62 included studies	Among the associations studied four or more times, correlates of nap duration were child's age and nighttime sleep onset/bedtime; correlates of nighttime sleep duration were household income, parent marital status, parental adiposity level, nighttime sleep duration at younger age, nighttime sleep onset/bedtime, nighttime sleep wakeup time, and frequency of current bedtime routine; correlate of total sleep duration was screen time
Morrissey *et al.*[42]	A systematic review of multiple sleep dimensions: 12 were included for detailed review	A significant inverse association between sleep duration and measured weight status

CI=Confidence interval, OR=Odds ratio, RR=Relative risk, BMI=Body mass index, MS=Multiple sclerosis, CAD=Coronary artery disease

Table 3: A summary of randomized controlled trial that assessed the impact of sleep duration on health after 2015

Authors	Study design	Study group	Intervention	Measurement	Results
Spaeth *et al.*[43]	Randomized controlled	Healthy adults (21-50 years)	An experimental (*n*=36; 4 h sleep/night for five nights followed by one night with 12 h recovery sleep) or control condition (*n*=11; 10 h sleep/night)	Resting metabolic rate and respiratory quotient in the morning after overnight fasting	Sleep restriction decreased morning resting metabolic rate in healthy adults
Santisteban *et al.*[44]	Randomized controlled	Healthy participants aged 18-34 years	An experimental (*n*=48; elimination of 1 h of sleep relative to the baseline habitual sleep duration) versus placebo (*n*=45; exposure to a lamp with no known therapeutic effect)	Working memory, sustained attention, response inhibition, and decision making	Cumulative partial sleep deprivation negatively affects performance on a test of working memory capacity but does not affect performance on tests of sustained attention, response inhibition, or decision-making
Cros *et al.*[45]	Randomized controlled	Healthy adults (21-50 years)	10 subjects exposed to a 6-day overfeeding period (130% daily energy needs, with 15% extra energy as sucrose and 15% as fat), with normal sleep (8 h sleep opportunity time) or sleep restriction (4 h sleep opportunity time), according to a randomized, crossover design. Crossover design was studied on 2 occasions, separated by a 4-8-week washout period	At baseline and after intervention, intrahepatocellular lipid concentrations were measured by proton magnetic resonance spectroscopy, and a dual intravenous [6, 6-2H2]-, oral 13C-labeled glucose tolerance test and a polysomnographic recording were performed	6 days of a high-sucrose, high-fat overfeeding diet significantly increased IHCL concentrations and increased endogenous glucose production, suggesting hepatic insulin resistance. These effects of overfeeding were not altered by sleep restriction
Ritland *et al.*[46]	Randomized-controlled	Young healthy athletes' adult (aged 18-30 years)	50 participants (experimental *n*=25) wore actigraphs for 15 consecutive nights and completed a cognitive/motor battery after seven habitual sleep nights, after four sleep extension nights (goal of spending 10 h in bed each night), and after the resumption of habitual sleep for four nights. The control group (control *n*=25) remained on habitual sleep schedules for the entire study	Performance testing took place after the first seven nights of habitual sleep (pretest), after the four-night intervention period (posttest), and after the four nights following the intervention period (follow-up)	Increasing sleep duration in military tactical athletes resulted in immediate performance benefits in psychomotor vigilance, executive functioning, standing broad jump distance, and motivation levels. Benefits on motor performance were evident 4 days after resumption of habitual sleep schedules
Tajiri *et al.*[47]	Randomized crossover design	Healthy women aged 21-22 years	Participants were 16, short sleep condition: 4 h/night (2:00-6:00) and a control sleep condition: 7 h/night (23:00-6:00); each condition comprised 3 consecutive nights	Energy intake and physical activity	Physical activity increases in the short sleep condition were attributed to differences in awake time between the conditions. However, there were no differences in energy intake

Contd...

Table 3: Contd...

Authors	Study design	Study group	Intervention	Measurement	Results
Hibi *et al.*[48]	Randomized crossover study	Healthy men aged 23±2 years	Nine healthy men were evaluated under two conditions: a 3.5-h sleep duration and a 7-h sleep duration for three consecutive nights followed by one 7 h recovery sleep night	Energy expenditure, substrate utilization, and core body temperature were continually measured for 48 h using a whole-room calorimeter. Appetite questionnaire every hour while in the calorimeter	Shortened sleep increased appetite by decreasing gastric hormone levels but did not affect energy expenditure, suggesting that greater caloric intake during a shortened sleep cycle increases the risk of weight gain
McNeil and St-Onge[49]	Randomized crossover trials	Healthy adult (18-45 years of age)	All participants (*n*=43); sleep restriction (3.5-4 h in bed per night) and habitual sleep (7-9 h in bed per night)	Ad libitum, 24-h energy intake was objectively assessed following sleep restriction and habitual sleep conditions	Large interindividual variations in energy intake following sleep restriction were noted, suggesting that not all participants were negatively impacted by the effects of sleep restriction
Al Khatib *et al.*[50]	Randomized controlled pilot study	Healthy men and women aged 18-64 years and with a BMI (in kg/m^2) of 18.5-<30	The sleep extension group (*n*=21) received a behavioral consultation session targeting sleep hygiene. The control group (*n*=21) maintained habitual short sleep	Sleep measured by wrist actigraphy. Assess the effects of extended sleep on dietary intake and quality measured by 7 days food diaries, resting and total energy expenditure, physical activity, and markers of cardiometabolic health	Showed the feasibility of extending sleep in adult short sleepers. Sleep extension led to reduced free sugar intakes and may be a viable strategy to facilitate limiting excessive consumption of free sugars in an obesity-promoting environment
Yang *et al.*[51]	Randomized crossover study	Women who reported habitually sleeping 7-9 h/night were aged 18-55	24 participants, sleep conditions in this study consisted of a normal night and a curtailed night where time in bed was reduced by 33%	Hunger, tiredness, sleep quality, sleepiness, and food cravings	Increased hunger, food cravings, food reward, and portion sizes of food after a night of modest sleep curtailment. These maladaptive responses could lead to higher energy intake and, ultimately, weight gain
Smith *et al.*[52]	Randomized controlled	Healthy males (ages 30-45 years)	Study 1 (*n*=14) involved severe, acute sleep restriction (4 h time in bed) versus habitual sleep (9 h time in bed) for 5 nights; Study 2 (*n*=13) consisted of mild, long-term sleep restriction (HS 1.5 h of sleep/night) versus habitual sleep for 6 weeks	Plasma testosterone levels	Sleep restriction does not adversely affect plasma testosterone levels in healthy young men
Wilms *et al.*[53]	Experimental Randomized control study	Fifteen healthy men aged 18-30 years	Fifteen healthy participants were studied. In randomized, balanced order, they underwent three separate nights with regular sleep duration (8 h of sleep between 11:00 PM and 7:00 AM), sleep restriction (4 h of sleep between 3:00 AM and 7:00 AM), and sleep deprivation (no sleep at all)	Sleep was polysomnographically evaluated. White adipose tissue biopsy samples were taken twice at 9:00 PM and 7:00 AM to assess morning-to-evening differences. White adipose tissue transcriptome profile was assessed by RNA sequencing, and expression of relevant	Acute sleep loss induces a profound restructuring of morning-to-evening WAT transcriptome with uncoupling from the local clock machinery, resulting in increased WAT carbohydrate turnover and impaired glucose homeostasis.

Contd...

Table 3: Contd...

Authors	Study design	Study group	Intervention	Measurement	Results
				circadian core clock genes was analyzed. Glucose homeostasis, lipid profile, and adipokines were assessed	Our data support an optimization of sleep duration and timing to prevent metabolic disorders such as obesity and type 2 diabetes
Full *et al.*[54]	Cross-sectional study	18 years of age or older, uncontrolled type 2 diabetes (A1C >7%)	317 Hispanic adults with uncontrolled type 2 diabetes who participated in an RCT testing a peer support intervention to improve diabetes control through improvements in management behaviors and utilization of healthcare services among patients with type 2 diabetes compared with a usual care condition	Glycemic control was assessed by A1C ascertained through medical chart review. Sleep duration, diabetes control behaviors, and demographics were obtained by interviewer-administered questionnaire	Sleep duration was not significantly associated with glycemic control in this sample of Hispanic adults with uncontrolled type 2 diabetes when adjusting for insulin
Ward *et al.*[55]	Randomized controlled trial	Children aged 8-12 years with normal reported sleep duration of 8-11 h/night	110 children will undergo 2 weeks of sleep manipulation; seven nights of sleep restriction by going to bed 1 h later than usual, and seven nights of sleep extension going to bed 1 h earlier than usual, separated by a washout week	24-h movement behaviors (sleep, physical activity, sedentary behavior) will be measured via actigraphy; dietary intake and context of eating by multiple 24-h recalls and wearable camera images; and eating behaviors via objective and subjective methods. At the end of each experimental week, a feeding experiment will determine energy intake from eating in the absence of hunger	Determining how insufficient sleep predisposes children to weight gain should provide much-needed information for improving interventions for the effective prevention of obesity, thereby decreasing long-term morbidity and healthcare burden

BMI=Body mass index, IHCL=Intrahepatocellular

Table 4: A summary of experimental studies that assessed the duration of daytime nap

Study	Design	Assessment	Results
Tietzel and Lack[56]	16 healthy adults Assessed the effects of no nap, 30 s nap, 90 s nap, and 10 min nap after restricting nocturnal sleep to 5 h	Subjective alertness, objective alertness, fatigue, vigor, and cognitive performance	The 10-min nap resulted in significantly improved alertness and cognitive performance relative to 30 s, 90 s, or a no-nap control
Tietzel and Lack[57]	12 young health adults Compared the effects of no nap, a 10 min nap, and a 30 min afternoon nap after restricting nocturnal sleep to 4.7	Objective and subjective alertness measures and cognitive performance measures were taken before, then 5, 35, and 60 min	The 10 min nap resulted in immediate improvement in subjective alertness and cognitive performance which was sustained for the h of post nap testing. Immediately following the 30 min nap, most measures of alertness and performance declined but showed some recovery by the end of testing
Brooks and Lack[58]	24 healthy, young adults slept for 5, 10, 20, or 30 min in the afternoon or participated in a no-nap condition, all following a night restricted to 5 h of sleep	Assessment of the underlying EEG changes that accompanied restorative nap benefits	The 5 min nap produced few benefits in comparison with the no-nap control. The 10 min nap produced immediate improvements in all outcome measures The 20 min nap improvements emerged 35 min after napping The 30 min nap produced a period of impaired alertness and performance immediately after napping, indicative of sleep inertia
Hayashi and Hori[59]	Participants went to bed at 12.20 h and were awakened after they slept for 20 min	The EEG recordings of relaxed wakefulness, mood, performance, and self-rating of performance level were measured every 20 min from 10.00 to 18.00 h	The nap improved subjective sleepiness and self-rating of task performance and suppressed EEG alpha activity
Hayashi *et al.*[60]	7 health adults underwent nap (14:00-14:20) and no-nap conditions at intervals of 1 week after a nocturnal sleep recording (00:00-08:00 h)	EEG recordings during relaxed wakefulness, and their mood, performance, and self-ratings of performance level were measured every 20 min from 10:00 to 18:00 h	The 20 min nap improved the subjective sleepiness, performance level, and self-confidence of their task performance The nap also suppressed EEG alpha activity during eyes-open wakefulness

EEG=Electroencephalography

Table 5: Review of available national studies on physical activity based on the inclusion criteria

Study	Study design	Definition of physical activity	Age	Sample size	Health status (1=healthy, 2=unhealthy)	Physical activity assessment methods	Regional location	Data collection years	MVPA Results	Notes
Al-Rasheed and Ibrahim[61]	Cross-sectional study	At least 60 min of MVPA/day	12-15 years old	62 Male=25 Female=37	1	Objective Accelerometer	Dammam	2018	MVPA=80.7-98.3 min/d	Normal sleep versus poor sleep
Mattoo *et al.*[62]	Comparative study	WHO guidelines	18-35 years old	Male=147 Female=93 Total=240	1 and 2	Subjective Questionnaire	Riyadh	2018-2019	MVPA=20%	Unclear results for physical activity
Alkhaldy *et al.*[63]	Cross-sectional study	Very active (≥40 point), active (39~30 point), moderately active (29~20 point), and inactive (<20 point) (Al-Hazzaa and Al-Ahmidi, 2003)	20-30 years old	Female=42	1	Subjective Questionnaire	Jeddah	2019	MPA=21%	0% of vigorous physical activity
Alzahrani *et al.*[64]	Cross-sectional study	≥150 min of MPA or≥90 min of VPA per week	25-75 years old	Male=92 Female=155 Total=247	2	Subjective Questionnaire	Jeddah	2018	MVPA=35.6%	
Aljuhani and Sandercock[65]	Cross-sectional study	At least 60 min of MVPA per day	12-14 years old	Male=123	1	Objective Accelerometer	Riyadh	2019	On physical education class days=40%, non-PE class days=24%	
Al-Hazzaa and Albawardi[66]	Cross-sectional study	METs-min/week (above or below 1680 METs-min/week)	15-19 years old	Male=1388 Female=1500 Total=2888	1	Subjective Questionnaire	Riyadh, Jeddah and AL-Khobar	2018	Male=3080 METs-min/week Female=1376 METs-min/week	
Almuzaini and Jradi[67]	Cross-sectional study	GPAQ classification, (1) low, (2) moderate, (3) intensive	18-60 years old	Male=395	1 & 2	Subjective Questionnaire	AL Madinah	2018	Moderate/ intense=34.9%	
Alharbi[68]	Cross-sectional study	The PAQ-C, categorized PA as low (≤2.3), moderate (2.4-3.7), and high (≥3.8) levels of PA	10-15 years old	Female=464	1	Subjective Questionnaire	Riyadh	2018	MVPA=77.6%	
Alzamil *et al.*[69]	Cross-sectional study	≥150 min of MVPA per week	18-28 years old	Female=456	1	Subjective Questionnaire	Riyadh	2018	MVPA=54.2	
Alhakbany *et al.*[70]	Cross-sectional study	Active (600+METs-min/week) Inactive (<600 METs-min/week)	20.3±1.5 years old	Female=454	1	Subjective Questionnaire	Riyadh	2017	Active=49.6% (600+METs-min/week) Inactive=50.4 (<600 METs-min/week)	

Contd...

Table 5: Contd...

Study	Study design	Definition of physical activity	Age	Sample size	Health status (1=healthy, 2=unhealthy)	Physical activity assessment methods	Regional location	Data collection years	MVPA Results	Notes
Al-Hazzaa[71]	Systematic review	Adults=≥150 min of MVPA/week Children and adolescents= ≥60 min of MVPA per day	5-70 years old	Total children=520, adolescents=9672, adults=26174	1	Objective and subjective	Riyadh, Jeddah, Al-Khobar, Abha, Dammam, Al-Ahsa region, National sample, Aseer Province	2018	The prevalence of physical activity, in general, ranged from 15% to 74% among Saudi males and from 9% to 57% among Saudi females, depending on the population measured, region, age, gender, the type of PA instrument utilized	
Alosaimi *et al.*[72]	Cross-sectional study	Aerobic activity ≥20 min twice weekly	38.0±13.0	Male=647 Female=538 Total=11185	2	Subjective Mini-interview form	Riyadh, Zulfi, Jeddah, Dammam, Aljouf, Abha	July 2012 and June 2014	Aerobic activity ≥20 min twice per week Male=15.9% Female=9.6% Total=12.9%	
Al-Kutbe *et al.*[73]	Cross-sectional	Evenson cut points	8-11 years	Female=78	1	Objective, accelerometer	Makkah	2017	Time in MVPA was 22.2, 20.9, 18.6, and 18.4 for UW, HW, OW, and OB, respectively	
Bajamal *et al.*[74]	Cross-sectional	60 min of MVPA per day	13-18	Female=405	1	Subjective Questionnaire	Jeddah	2017	Mean PA level was low 2.1	
Alkahtani[75]	Convergent validity	Freedson cut-points	20±1.1 years	Male=62	1	Objective Accelerometer	Dammam	2016	Time in MVPA was 273.5 m/w	
Albawardi *et al.*[76]	Cross-sectional	Low: <600 MET min/week; moderate: 600-2999 MET min/week; high: ≥1500 MET min/week vigorous PA or ≥3000 MET min/week moderate/vigorous PA	18-58	Female=420	1	Subjective Questionnaire	Riyadh	2015	47.9% of sample were physically active	

Contd...

Table 5: Contd...

Study	Study design	Definition of physical activity	Age	Sample size	Health status (1=healthy, 2=unhealthy)	Physical activity assessment methods	Regional location	Data collection years	MVPA Results	Notes
El Bcheraoui *et al.*[77]	Cross-sectional	PA classified into 4 groups: (a) met VPA, or a minimum of 300 metabolic equivalent minutes (MET-min)/week; (b) met MPA, or 150-300 MET min/week; (c) do not meet VPA or MPA levels, or 0 to <150 MET-min/week	15+	Total male and female=10,735	1 and 2	Subjective Questionnaire	KSA	2013	1.7 million (12.9%) meet the recommended levels of MPA	
Alghadir *et al.*[78]	Cross-sectional	Physical activity level; mild (≤500 METs-min/week), moderate (500-2500 METs-min/week), or active (≥2500 METs-min/week)	8-18 years	Male=90 Female=90	1	Subjective Questionnaire	Riyadh	2013-2014	Mild (*n*=40 (male=10, female=30); 22.2%), moderate (*n*=35 (male=15, female=20); 19.4%), active (*n*=105 (male=65, female=40); 58.3%)	
Al-Sobayel *et al.*[79]	Cross-sectional	60 min of MVPA/day	14-19 years	Male=1,388 Female=1,500	1	Subjective Questionnaire	Riyadh, Jeddah, and Al-Khobar	2009-2010	All sample spent 90 in LTPA and 77 in non-LTPA. LTPA in male was 395 (m/w) and 101 (m/w) in female Non-LTPA in male was 139 (m/w) and 145 (m/w) in female	
Alkahtani *et al.*[80]	Cross-sectional	Freedson cut-points	37.6±8.8 years	Male=84	1	Objective Accelerometer	Dammam	2015	Daily MVPA was 34.0 m/d	

MVPA=Moderate to vigorous physical activity, MPA=Moderate physical activity, PA=Physical activity, PE=Physical education, GPAQ=Global physical activity questionnaire, VPA=Vigorous physical activity, MET=Metabolic equivalents

Table 6: Review of available national studies on the relationship between physical activity and health outcomes based on the inclusion criteria

Study	Study design	Sample details	Assessment methods	Health outcomes Results	Type of disease
Al-Kutbe *et al.*[73]	A cross-sectional observational study	266 females, (8-11 years) Only 78 complete physical activity measurement	Objective Accelerometer	Total energy expenditure per kg of body weight had a significant negative influence on body weight (β=–0.661, *P*<0.001)	Obesity
Alhusaini *et al.*[81]	Cross-sectional study	85 children (8-12 years)	Objective Pedometer	Obesity and physical inactivity among Saudi Arabian children with and without down syndrome are major health concerns	Obesity in healthy and mental disable children
Ahmed *et al.*[82]	Cross-sectional study	299 males and females (10-15 years)	Subjective Questionnaire	Physical activity was significantly and inversely associated with overweight and obesity in boys, but not in girls	Obesity
Al-Nakeeb *et al.*[83]	Cross-sectional study	1,138 males and females (15-17 years)	Subjective Questionnaire	Higher BMI reported lower levels of physical activity	Obesity
Al-Nuaim *et al.*[84]	Cross-sectional study	1270 males and females (15-19 years)	Subjective Questionnaire	Normal weight males reported the highest levels of physical activity compared to overweight and obese	Obesity
Mattoo *et al.*[62]	Comparative study	240 males and females (18-35 years)	Subjective Questionnaire	A high prevalence of inactivity was observed among families in the overweight/obese group	Obesity
Alramadan *et al.*[85]	Cross-sectional study	1111 males and females (75.6±11.1 years)	Subjective Questionnaire	Low level of physical activity was independent risk factors for inadequate glycemic control	Diabetes
Wani *et al.*[86]	12-month two-arm randomized controlled	300 males and females, (20-73 years)	Subjective Questionnaire	Intensive lifestyle program implemented in a primary health care setting was effective in decreasing weight and improving glycemic status in predominantly. Overweight/obese Saudi adults with prediabetes.	Diabetes
Alkahtani *et al.*[80]	Cross-sectional study	84 healthy men (37.6±8.8 years)	Objective Accelerometer	Low physical activity and 10-min of MVPA were associated with elevated HDL levels among Saudi men	Metabolic syndrome
Al-Hamdan *et al.*[87]	Cross-sectional study	4758 males and females, (15-64 years old)	Subjective Questionnaire	Hypertension was significantly negatively associated with total levels and duration of physical activity in leisure, transport, and work	Hypertension
Alsareii *et al.*[88]	An online-based, anonymous, self-rating, cross-sectional and survey-based study	300 females (232 college students and 68 faculty staff)	Subjective Questionnaire	Lack of physical activity (66.3%) and family history of breast cancer (18%) were the most substantial nonobstetric risk factors of breast cancer	Breast cancer
Alkahtani *et al.*[89]	Cross-sectional study	497 males, (32.2±10.4 years)	Subjective Questionnaire	Physical activity independent of exercise intensity was directly associated with appendicular lean mass and indirectly associated with bone mineral density through increased muscle mass and strength	Sarcopenia
Alenazi *et al.*[90]	Randomized Controlled Trial	181 (males and females), (60.7±11.8 years)	Objective StepWatch	Physical activity level was not contributing factors to falls in elderly with chronic stroke	Injury

Contd...

Table 6: Contd...

Study	Study design	Sample details	Assessment methods	Health outcomes Results	Type of disease
Al-Rasheed and Ibrahim[61]	Cross-sectional study	62 males and females, (12-15 years old)	Objective Accelerometer	Physical activity parameters including the total steps count, total activities count, activity rate, and the vigorous activity time were significantly lower in poor sleep group	Poor sleep
Al-Eisa *et al.*[91]	Cross-sectional study	67 females (20.9±1.4 years)	Objective Pedometer	Physical activity was negatively correlated with insomnia severity index (r=−0.74) and Beck depression inventory (r=−0.78) and positively correlated with attention span test (r=0.69)	Psychological diseases
Al-Hariri[92]	Cross-sectional study	60 males, (18-60 years old)	Subjective Interview survey	Patients who exercise running or jogging activities have better feeling while they run	Psychological diseases
Al-Eisa and Al-Sobayel[93]	Cross-sectional study	105 males (26.3±7.1 years)	Objective Pedometer	There is an association between physical activity and health beliefs. Step count had strong correlation with self-efficacy (r=0.75), mild correlation with internal health locus of control (r=0.42), and mild negative correlation with external health locus of control (r=−0.35)	Psychological factors
Al-Eisa E. *et al.*[94]	Experimental study	62 females, (21±1.5 years)	Objective Pedometer	Moderate negative correlation between physical activity and insomnia severity index scores after the 3 weeks motivation program	Psychological diseases
Al-Zoughool *et al.*[95]	Cross-sectional study	303 males and females (53.7±12.2)	Subjective Questionnaire	Moderate occupational PA was associated with >60% reduction in coronary heart disease risk	Coronary heart disease
Aljuhani and Sandercock[65]	Cross-sectional study	123 males, (12-14 years old)	Objective Accelerometer	On physical education class days=40%, Non-PE class days=24%. Active schoolchildren obtained a higher cardiorespiratory fitness	General health (cardiorespiratory fitness)

BMI=Body mass index, MVPA=Moderate to vigorous physical activity, PE=Physical education, PA=Physical activity, HDL=High-density lipoprotein

Table 7: Review of available Saudi studies characteristics (design, demographics, and location and time of data collection) reporting on sedentary behavior

Study	Study design	Study details	Study sedentary behavior definition	Total sedentary behavior[a]	Assessment method	Regional location	Special conditions
Al-Baghli *et al.*[96]	Screening campaign for the early detection of DM and hypertension	Included people aged>29 from both sexes, excluding pregnant women (*n*=197,681)	No physical activity (completely sedentary lifestyle, e.g., reading, watching TV)	NA	Subjective questions	Eastern province	Sample included people with DM and HTN
Al-Hazzaa *et al.*[66,79,97]	Cross-sectional	Included people aged 14-19 from both sexes (*n*=2908)	Typical daily time spent on sedentary activities, including time spent viewing TV, playing video games, and computer and Internet use	Female: 6.6[b] Male: 5.3b	Subjective questions	Riyadh, Jeddah, and Al-Khobar	NA
Al-Nakeeb *et al.*[83]	Cross-sectional	Included people aged 15-17 from both sexes (*n*=1138)	Typical daily time spent on sedentary activities, including time spent viewing TV, playing video games, and computer and Internet use	Female: 5.78±2.57 Male: 4.99±3.02	Subjective questions	Alhasa	NA
Alkahtani *et al.*[80]	Cross-sectional	Included men aged ≥20 (*n*=84)	Sedentary behavior is any activity during which energy expenditure is ≤1.5 METs, such as sitting or standing	8.9[c]	Objective sedentary; ActiGraph 0-99 counts	Dammam and Al-Khobar	Office workers
Alghadir *et al.*[78]	Cross-sectional	Included people aged 8-18 from both sexes (*n*=180)	TV viewing time: The time spent watching TV, videotapes, or DVDs, while computer time: The time spent on a home computer or playing video games	5.45[c]	Internet based survey	Not specified	Students
Moradi-Lakeh *et al.*[98]	Cross-sectional national multistage survey	Included people aged ≥15 from both sexes (*n*=10,735)	In a typical week, how much time do you usually spend in front of the television or on the computer?	NA	Subjective	All	NA
Al-Agha *et al.*[99]	Retrospective cross-sectional	Included people aged 2-18 from both sexes (*n*=541)	Parents were asked how long their children spent watching TV, how often they used other electronic devices, such as tablets, cell phones, video game consoles, and computers	NA	Subjective	Jeddah	NA
Alkahtani[75]	Cross-sectional comparison of measures design	Included men aged≥18, (*n*=96)	Sedentary was 0-99 counts/min based on ActiGraph	6.0[b]	Objective and subjective	Dammam	1[st] year college students
Albawardi *et al.*[100]	Cross-sectional	Included women aged 18-60 (*n*=420)	Sitting and low levels of energy expenditure (1-1.5 METs)	Workday: 11.35±3.65 Nonworkday: 9.43±4.52	Subjective	Riyadh	Office-based (necessitating little physical work)
Khabaz *et al.*[101]	Cross-sectional	Included men aged 18-26, (*n*=116)	Hours spend on watching TV, using internet, Play station per day	NA	Subjective	Rabigh	Healthy students

Contd...

Table 7: Contd...

Study	Study design	Study details	Study sedentary behavior definition	Total sedentary behavior[a]	Assessment method	Regional location	Special conditions
Al-Zoughool *et al.*[95]	Cross-sectional	Included people from both sexes (*n*=303) (146 CHD cases aged 53.7±9 and 157 controls age 49.4±7)	Number of h/day of sedentary behavior	C: 4.52±2.57 CHD: 6.7±3.61	Subjective	Riyadh	CHD cases and controls
Alyami *et al.*[102]	Cross-sectional	Included men aged ≥40, n=66 (COPD: 34 aged 61.9±5.2, C: 32, aged 63.1±3.6)	Sedentary behavior was defined as 0 steps/min	C: 8.67±1 COPD: 10.48±1.33	Objective	Riyadh	COPD
Alhakbany *et al.*[70]	Cross-sectional	Included women aged ≥18, (*n*=454)	Typical daily time spent on sedentary activities, including time spent viewing TV, playing video games, and computer and Internet use	Normal BMI: 5.6±2.5 BMI>25: 5.4±2.5	Subjective	Riyadh	Health colleges students
AlQuaiz *et al.*[103]	Cross-sectional	Included people aged 30-75 from both sexes (*n*=2997)	Sitting time, which was considered an indicator of time spent in sedentary activity	6.0±3.5	Subjective	Riyadh	Non-Saudis, pregnant women and those with cognitive impairment were not included

[a]Duration dimension (how many minutes of sitting or reclining position for 60 min or more), reported in hours as mean±SD, [c]No reported standard deviation. DM=Diabetes mellitus, HTN=Hypertension, CHD=Coronary heart disease, COPD=Chronic obstructive pulmonary disease, BMI=Body mass index, SD=Standard deviation, NA=Not available, MET=Metabolic equivalents

References

1. Wiersma R, Haverkamp BF, van Beek JH, Riemersma AM, Boezen HM, Smidt N, *et al*. Unravelling the association between accelerometer-derived physical activity and adiposity among preschool children: A systematic review and meta-analyses. Obes Rev 2020;21:e12936.
2. Sousa-Sá E, Zhang Z, Pereira JR, Wright IM, Okely AD, Santos R. Systematic review on retinal microvasculature, physical activity, sedentary behaviour and adiposity in children and adolescents. Acta Paediatr 2020;109:1956-73.
3. Sampasa-Kanyinga H, Colman I, Goldfield GS, Janssen I, Wang J, Podinic I, *et al*. Combinations of physical activity, sedentary time, and sleep duration and their associations with depressive symptoms and other mental health problems in children and adolescents: A systematic review. Int J Behav Nutr Phys Act 2020;17:72.
4. Königstein K, Klenk C, Appenzeller-Herzog C, Hinrichs T, Schmidt-Trucksäss A. Impact of sedentary behavior on large artery structure and function in children and adolescents: A systematic review. Eur J Pediatr 2020;179:17-27.
5. Jones M, Defever E, Letsinger A, Steele J, Mackintosh KA. A mixed-studies systematic review and meta-analysis of school-based interventions to promote physical activity and/or reduce sedentary time in children. J Sport Health Sci 2020;9:3-17.
6. van de Kolk I, Verjans-Janssen SR, Gubbels JS, Kremers SP, Gerards SM. Systematic review of interventions in the childcare setting with direct parental involvement: Effectiveness on child weight status and energy balance-related behaviours. Int J Behav Nutr Phys Act 2019;16:110.
7. Smith JJ, Eather N, Weaver RG, Riley N, Beets MW, Lubans DR. Behavioral correlates of muscular fitness in children and adolescents: A systematic review. Sports Med 2019;49:887-904.
8. Parajára MD, de Castro BM, Coelho DB, Meireles AL. Are neighborhood characteristics associated with sedentary behavior in adolescents? A systematic review. Int J Environ Health Res 2020;30:388-408.
9. Bedard C, St John L, Bremer E, Graham JD, Cairney J. A systematic review and meta-analysis on the effects of physically active classrooms on educational and enjoyment outcomes in school age children. PLoS One 2019;14:e0218633.
10. Zabatiero J, Ng L, Clayton R, Middlemiss S, Kang K, Harrold M, *et al*. Effectiveness of interventions aiming at reducing sedentary behaviour in a non-surgical population with overweight or obesity: A systematic review and meta-analysis. Obes Res Clin Pract 2019;13:115-28.
11. Stanczykiewicz B, Banik A, Knoll N, Keller J, Hohl DH, Rosińczuk J, *et al*. Sedentary behaviors and anxiety among children, adolescents and adults: A systematic review and meta-analysis. BMC Public Health 2019;19:459.
12. Yan S, Fu W, Wang C, Mao J, Liu B, Zou L, *et al*. Association between sedentary behavior and the risk of dementia: A systematic review and meta-analysis. Translat Psychiatry 2020;10:112.
13. Peachey MM, Richardson J, V Tang A, Dal-Bello Haas V, Gravesande J. Environmental, behavioural and multicomponent interventions to reduce adults' sitting time: A systematic review and meta-analysis. Br J Sports Med 2020;54:315-25.
14. Olanrewaju O, Stockwell S, Stubbs B, Smith L. Sedentary behaviours, cognitive function, and possible mechanisms in older adults: A systematic review. Aging Clin Exp Res 2020;32:969-84.
15. Lutz N, Clarys P, Koenig I, Deliens T, Taeymans J, Verhaeghe N. Health economic evaluations of interventions to increase physical activity and decrease sedentary behavior at the workplace: A systematic review. Scand J Work Environ Health 2020;46:127-42.

16. Landais LL, Damman OC, Schoonmade LJ, Timmermans DR, Verhagen EA, Jelsma JG. Choice architecture interventions to change physical activity and sedentary behavior: A systematic review of effects on intention, behavior and health outcomes during and after intervention. Int J Behav Nutr Phys Act 2020;17:47.
17. Stone CR, Haig TR, Fiest KM, McNeil J, Brenner DR, Friedenreich CM. The association between sleep duration and cancer-specific mortality: A systematic review and meta-analysis. Cancer Causes Control 2019;30:501-25.
18. Chen Y, Tan F, Wei L, Li X, Lyu Z, Feng X, *et al*. Sleep duration and the risk of cancer: A systematic review and meta-analysis including dose-response relationship. BMC Cancer 2018;18:1149.
19. da Silva AA, de Mello RG, Schaan CW, Fuchs FD, Redline S, Fuchs SC. Sleep duration and mortality in the elderly: A systematic review with meta-analysis. BMJ Open 2016;6:e008119.
20. Lu C, Sun H, Huang J, Yin S, Hou W, Zhang J, *et al*. Long-term sleep duration as a risk factor for breast cancer: Evidence from a systematic review and dose-response meta-analysis. Biomed Res Int 2017;2017:4845059.
21. Jike M, Itani O, Watanabe N, Buysse DJ, Kaneita Y. Long sleep duration and health outcomes: A systematic review, meta-analysis and meta-regression. Sleep Med Rev 2018;39:25-36.
22. Itani O, Jike M, Watanabe N, Kaneita Y. Short sleep duration and health outcomes: A systematic review, meta-analysis, and meta-regression. Sleep Med 2017;32:246-56.
23. Yin J, Jin X, Shan Z, Li S, Huang H, Li P, *et al*. Relationship of sleep duration with all-cause mortality and cardiovascular events: A systematic review and dose-response meta-analysis of prospective cohort studies. J Am Heart Assoc 2017;6:e005947. doi: 10.1161/JAHA.117.005947.
24. Kwok CS, Kontopantelis E, Kuligowski G, Gray M, Muhyaldeen A, Gale CP, *et al*. Self-reported sleep duration and quality and cardiovascular disease and mortality: A dose-response meta-analysis. J Am Heart Assoc 2018;7:e008552.
25. Xi B, He D, Zhang M, Xue J, Zhou D. Short sleep duration predicts risk of metabolic syndrome: A systematic review and meta-analysis. Sleep Med Rev 2014;18:293-7.
26. Kruisbrink M, Robertson W, Ji C, Miller MA, Geleijnse JM, Cappuccio FP. Association of sleep duration and quality with blood lipids: A systematic review and meta-analysis of prospective studies. BMJ Open 2017;7:e018585.
27. Irwin MR, Olmstead R, Carroll JE. Sleep disturbance, sleep duration, and inflammation: A systematic review and meta-analysis of cohort studies and experimental sleep deprivation. Biol Psychiatry 2016;80:40-52.
28. Anothaisintawee T, Reutrakul S, Van Cauter E, Thakkinstian A. Sleep disturbances compared to traditional risk factors for diabetes development: Systematic review and meta-analysis. Sleep Med Rev 2016;30:11-24.
29. Wang D, Li W, Cui X, Meng Y, Zhou M, Xiao L, *et al*. Sleep duration and risk of coronary heart disease: A systematic review and meta-analysis of prospective cohort studies. Int J Cardiol 2016;219:231-9.
30. He Q, Sun H, Wu X, Zhang P, Dai H, Ai C, *et al*. Sleep duration and risk of stroke: A dose-response meta-analysis of prospective cohort studies. Sleep Med 2017;32:66-74.
31. Li W, Wang D, Cao S, Yin X, Gong Y, Gan Y, *et al*. Sleep duration and risk of stroke events and stroke mortality: A systematic review and meta-analysis of prospective cohort studies. Int J Cardiol 2016;223:870-6.
32. Lo JC, Groeger JA, Cheng GH, Dijk DJ, Chee MW. Self-reported sleep duration and cognitive performance in older adults: A systematic review and meta-analysis. Sleep Med 2016;17:87-98.
33. Shan Z, Ma H, Xie M, Yan P, Guo Y, Bao W, *et al*. Sleep duration and risk of type 2 diabetes: A meta-analysis of prospective studies. Diabetes Care 2015;38:529-37.
34. Felső R, Lohner S, Hollódy K, Erhardt É, Molnár D. Relationship between sleep duration and childhood obesity: Systematic review including the potential underlying mechanisms. Nutr Metab Cardiovasc Dis 2017;27:751-61.
35. Krietsch KN, Chardon ML, Beebe DW, Janicke DM. Sleep and weight-related factors in youth: A systematic review of recent studies. Sleep Med Rev 2019;46:87-96.
36. Chiu HY, Lee HC, Chen PY, Lai YF, Tu YK. Associations between sleep duration and suicidality in adolescents: A systematic review and dose-response meta-analysis. Sleep Med Rev 2018;42:119-26.
37. Short MA, Blunden S, Rigney G, Matricciani L, Coussens S, M Reynolds C, *et al*. Cognition and objectively measured sleep duration in children: A systematic review and meta-analysis. Sleep Health 2018;4:292-300.
38. Miller MA, Kruisbrink M, Wallace J, Ji C, Cappuccio FP. Sleep duration and incidence of obesity in infants, children, and adolescents: A systematic review and meta-analysis of prospective studies. Sleep 2018;41. doi:10.1093/sleep/zsys018.
39. Chaput JP, Gray CE, Poitras VJ, Carson V, Gruber R, Birken CS, *et al*. Systematic review of the relationships between sleep duration and health indicators in the early years (0-4 years). BMC Public Health 2017;17:855.
40. Wu Y, Gong Q, Zou Z, Li H, Zhang X. Short sleep duration and obesity among children: A systematic review and meta-analysis of prospective studies. Obes Res Clin Pract 2017;11:140-50.
41. Zhang Z, Sousa-Sá E, Pereira JR, Okely AD, Feng X, Santos R. Correlates of sleep duration in early childhood: A systematic review. Behav Sleep Med 2020:1-9. doi:10.1080/15402002.2020.1772264.
42. Morrissey B, Taveras E, Allender S, Strugnell C. Sleep and obesity among children: A systematic review of multiple sleep dimensions. Pediatr Obes 2020;15:e12619.
43. Spaeth AM, Dinges DF, Goel N. Resting metabolic rate varies by race and by sleep duration. Obesity (Silver Spring) 2015;23:2349-56.
44. Santisteban JA, Brown TG, Ouimet MC, Gruber R. Cumulative mild partial sleep deprivation negatively impacts working memory capacity but not sustained attention, response inhibition, or decision making: A randomized controlled trial. Sleep Health 2019;5:101-8.
45. Cros J, Pianezzi E, Rosset R, Egli L, Schneiter P, Cornette F, *et al*. Impact of sleep restriction on metabolic outcomes induced by overfeeding: A randomized controlled trial in healthy individuals. Am J Clin Nutr 2019;109:17-28.
46. Ritland BM, Simonelli G, Gentili RJ, Smith JC, He X, Mantua J, *et al*. Effects of sleep extension on cognitive/motor performance and motivation in military tactical athletes. Sleep Med 2019;58:48-55.
47. Tajiri E, Yoshimura E, Hatamoto Y, Tanaka H, Shimoda S. Effect of sleep curtailment on dietary behavior and physical activity: A randomized crossover trial. Physiol Behav 2018;184:60-7.
48. Hibi M, Kubota C, Mizuno T, Aritake S, Mitsui Y, Katashima M, *et al*. Effect of shortened sleep on energy expenditure, core body temperature,

and appetite: A human randomised crossover trial. Sci Rep 2017;7:39640.
49. McNeil J, St-Onge MP. Increased energy intake following sleep restriction in men and women: A one‐size‐fits‐all conclusion? Obesity 2017;25:989-92.
50. Al Khatib HK, Hall WL, Creedon A, Ooi E, Masri T, McGowan L, *et al*. Sleep extension is a feasible lifestyle intervention in free-living adults who are habitually short sleepers: A potential strategy for decreasing intake of free sugars? A randomized controlled pilot study. Am J Clin Nutr 2018;107:43-53.
51. Yang CL, Schnepp J, Tucker RM. Increased hunger, food cravings, food reward, and portion size selection after sleep curtailment in women without obesity. Nutrients 2019;11:663.
52. Smith I, Salazar I, RoyChoudhury A, St-Onge MP. Sleep restriction and testosterone concentrations in young healthy males: Randomized controlled studies of acute and chronic short sleep. Sleep Health 2019;5:580-6.
53. Wilms B, Leineweber EM, Mölle M, Chamorro R, Pommerenke C, Salinas-Riester G, *et al*. Sleep loss disrupts morning-to-evening differences in human white adipose tissue transcriptome. J Clin Endocrinol Metab 2019;104:1687-96.
54. Full KM, Schmied EA, Parada H, Cherrington A, Horton LA, Ayala GX. The relationship between sleep duration and glycemic control among Hispanic adults with uncontrolled type 2 diabetes. Diabetes Educ 2017;43:519-29.
55. Ward AL, Galland BC, Haszard JJ, Meredith-Jones K, Morrison S, McIntosh DR, *et al*. The effect of mild sleep deprivation on diet and eating behaviour in children: Protocol for the Daily Rest, Eating, and Activity Monitoring (DREAM) randomized cross-over trial. BMC Public Health 2019;19:1347.
56. Tietzel AJ, Lack LC. The recuperative value of brief and ultra-brief naps on alertness and cognitive performance. J Sleep Res 2002;11:213-8.
57. Tietzel AJ, Lack LC. The short-term benefits of brief and long naps following nocturnal sleep restriction. Sleep 2001;24:293-300.
58. Brooks A, Lack L. A brief afternoon nap following nocturnal sleep restriction: Which nap duration is most recuperative? Sleep 2006;29:831-40.
59. Hayashi M, Hori T. The effects of a 20-min nap before post-lunch dip. Psychiatry Clin Neurosci 1998;52:203-4.
60. Hayashi M, Watanabe M, Hori T. The effects of a 20 min nap in the mid-afternoon on mood, performance and EEG activity. Clin Neurophysiol 1999;110:272-9.
61. Al-Rasheed AS, Ibrahim AI. Does the poor sleep quality affect the physical activity level, postural stability, and isometric muscle strength in Saudi adolescents? A comparative study. Saudi Med J 2020;41:94-7.
62. Mattoo K, Shubayr M, Moaleem MA, Halboub E. Influence of parental physical activity and screen time on the BMI of adult offspring in a Saudi population. Healthcare (Basel) 2020;8:110.
63. Alkhaldy AA, Rizq NK, Del Jaylan SA, Alkendi EA, Alghamdi WM, Alfaraidi SM. Dietary intake and physical activity in relation to insulin resistance in young overweight Saudi females: An exploratory pilot study. Prev Nutr Food Sci 2019;24:373-80.
64. Alzahrani AM, Albakri SB, Alqutub TT, Alghamdi AA, Rio AA. Physical activity level and its barriers among patients with type 2 diabetes mellitus attending primary healthcare centers in Saudi Arabia. J Family Med Prim Care 2019;8:2671-5.
65. Aljuhani O, Sandercock G. Contribution of physical education to the daily physical activity of schoolchildren in Saudi Arabia. Int J Environ Res Public Health 2019;16:2397.
66. Al-Hazzaa HM, Albawardi NM. Activity energy expenditure, screen time and dietary habits relative to gender among Saudi youth: Interactions of gender with obesity status and selected lifestyle behaviours. Asia Pac J Clin Nutr 2019;28:389-400.
67. Almuzaini Y, Jradi H. Correlates and levels of physical activity and body mass index among Saudi men working in office-based jobs. J Community Health 2019;44:815-21.
68. Alharbi M. Influence of individual and family factors on physical activity among Saudi girls: A cross-sectional study. Ann Saudi Med 2019;39:13-21.
69. Alzamil HA, Alhakbany MA, Alfadda NA, Almusallam SM, Al-Hazzaa HM. A profile of physical activity, sedentary behaviors, sleep, and dietary habits of Saudi college female students. J Family Community Med 2019;26:1-8.
70. Alhakbany MA, Alzamil HA, Alabdullatif WA, Aldekhyyel SN, Alsuhaibani MN, Al-Hazzaa HM. Lifestyle habits in relation to overweight and obesity among saudi women attending health science colleges. J Epidemiol Glob Health 2018;8:13-9.
71. Al-Hazzaa HM. Physical inactivity in Saudi Arabia revisited: A systematic review of inactivity prevalence and perceived barriers to active living. Int J Health Sci (Qassim) 2018;12:50-64.
72. Alosaimi FD, Abalhasan MF, Alhabbad AA, Fallata EO, Haddad BA, AlQattan NI, *et al*. Prevalence and determinants of physical activity in a mixed sample of psychiatric patients in Saudi Arabia. Saudi Med J 2018;39:401-11.
73. Al-Kutbe R, Payne A, de Looy A, Rees GA. A comparison of nutritional intake and daily physical activity of girls aged 8-11 years old in Makkah, Saudi Arabia according to weight status. BMC Public Health 2017;17:592.
74. Bajamal E, Robbins LB, Ling J, Smith B, Pfeiffer KA, Sharma D. Physical activity among female adolescents in Jeddah, Saudi Arabia: A health promotion model-based path analysis. Nurs Res 2017;66:473-82.
75. Alkahtani SA. Convergent validity: Agreement between accelerometry and the Global Physical Activity Questionnaire in college-age Saudi men. BMC Res Notes 2016;9:436.
76. Albawardi NM, Jradi H, Al-Hazzaa HM. Levels and correlates of physical activity, inactivity and body mass index among Saudi women working in office jobs in Riyadh city. BMC Womens Health 2016;16:33.
77. El Bcheraoui C, Tuffaha M, Daoud F, Kravitz H, Al Mazroa MA, Al Saeedi M, *et al*. On Your mark, get set, go: Levels of physical activity in the Kingdom of Saudi Arabia, 2013. J Phys Act Health 2016;13:231-8.
78. Alghadir AH, Gabr SA, Iqbal ZA. Effects of sitting time associated with media consumption on physical activity patterns and daily energy expenditure of Saudi school students. J Phys Ther Sci 2015;27:2807-12.
79. Al-Sobayel H, Al-Hazzaa HM, Abahussain NA, Qahwaji DM, Musaiger AO. Gender differences in leisure-time versus non-leisure-time physical activity among Saudi adolescents. Ann Agric Environ Med 2015;22:344-8.
80. Alkahtani S, Elkilany A, Alhariri M. Association between sedentary and physical activity patterns and risk factors of metabolic syndrome in Saudi men: A cross-sectional study. BMC Public Health 2015;15:1234.
81. Alhusaini AA, Ali Al-Walah M, Melam GR, Buragadda S. Pedometer-determined physical activity levels of healthy children and children with Down's syndrome. Somatosens Mot Res 2017;34:219-25.

82. Ahmed HS, Khalid ME, Osman OM, Ballal MA, Al-Hashem FH. The association between physical activity and overweight and obesity in a population of children at high and low altitudes in Southwestern Saudi Arabia. J Family Community Med 2016;23:82-7.
83. Al-Nakeeb Y, Lyons M, Collins P, Al-Nuaim A, Al-Hazzaa H, Duncan MJ, *et al*. Obesity, physical activity and sedentary behavior amongst British and Saudi youth: A cross-cultural study. Int J Environ Res Public Health 2012;9:1490-506.
84. Al-Nuaim AA, Al-Nakeeb Y, Lyons M, Al-Hazzaa HM, Nevill A, Collins P, *et al*. The prevalence of physical activity and sedentary behaviours relative to obesity among adolescents from Al-Ahsa, Saudi Arabia: Rural versus Urban Variations. J Nutr Metab 2012;2012:417589.
85. Alramadan MJ, Magliano DJ, Almigbal TH, Batais MA, Afroz A, Alramadhan HJ, *et al*. Glycaemic control for people with type 2 diabetes in Saudi Arabia - An urgent need for a review of management plan. BMC Endocr Disord 2018;18:62.
86. Wani K, Alfawaz H, Alnaami AM, Sabico S, Khattak MNK, Al-Attas O, *et al*. Effects of a 12-month intensive lifestyle monitoring program in predominantly overweight/obese Arab adults with prediabetes. Nutrients 2020;12:464.
87. Al-Hamdan NA, Al-Zalabani AH, Saeed AA. Comparative study of physical activity of hypertensives and normotensives: A cross-sectional study of adults in Saudi Arabia. J Family Community Med 2012;19:162-6.
88. Alsareii SA, Alqahtani SM, Alamri AM, Al-Wadei HH, Al-Ammari SA, Al-Qahtani AM, *et al*. Awareness of breast cancer among female students and faculty from Najran University, Najran, Saudi Arabia. Asian Pac J Cancer Prev 2020;21:1415-22.
89. Alkahtani S, Aljaloud K, Yakout S, Al-Daghri NM. Interactions between sedentary and physical activity patterns, lean mass, and bone density in Arab men. Dis Markers 2019;2019:5917573.
90. Alenazi AM, Alshehri MM, Alothman S, Rucker J, Dunning K, D'Silva LJ, *et al*. Functional reach, depression scores, and number of medications are associated with number of falls in people with chronic stroke. PM R 2018;10:806-16.
91. Al-Eisa E, Buragadda S, Melam GR. Association between physical activity and psychological status among Saudi female students. BMC Psychiatry 2014;14:238.
92. Al-Hariri M. Life style activities and feeling state responses in community sample of diabetic patients in Eastern Providence Saudi Arabia. J Diabetes Metab Disord 2019;18:301-5.
93. Al-Eisa ES, Al-Sobayel HI. Physical activity and health beliefs among Saudi women. J Nutr Metab 2012;2012:642187.
94. Al-Eisa E, Buragadda S, Melam GR, Al-Osaimi AO, Al-Mubarak HA, Al-Huwaimel NA. Association between physical activity and insomnia among Saudi female college students. J Phys Ther Sci 2013;25:1479-82.
95. Al-Zoughool M, Al-Ahmari H, Khan A. Patterns of physical activity and the risk of coronary heart disease: A pilot study. Int J Environ Res Public Health 2018;15:778.
96. Al-Baghli NA, Al-Turki KA, Al-Ghamdi AJ, El-Zubaier AG, Al-Ameer MM, Al-Baghli FA. Control of diabetes mellitus in the Eastern Province of Saudi Arabia: Results of screening campaign. East Mediterr Health J 2010;16:621-9.
97. Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Musaiger AO. Physical activity, sedentary behaviors and dietary habits among Saudi adolescents relative to age, gender and region. Int J Behav Nutr Phys Act 2011;8:140.
98. Moradi-Lakeh M, El Bcheraoui C, Tuffaha M, Daoud F, Al Saeedi M, Basulaiman M, *et al*. Self-rated health among Saudi Adults: Findings from a National Survey, 2013. J Community Health 2015;40:920-6.
99. Al-Agha AE, Nizar FS, Nahhas AM. The association between body mass index and duration spent on electronic devices in children and adolescents in Western Saudi Arabia. Saudi Med J 2016;37:436-9.
100. Albawardi NM, Jradi H, Almalki AA, Al-Hazzaa HM. Level of sedentary behavior and its associated factors among Saudi women working in office-based jobs in Saudi Arabia. Int J Environ Res Public Health 2017;14:659.
101. Khabaz MN, Bakarman MA, Baig M, Ghabrah TM, Gari MA, Butt NS, *et al*. Dietary habits, lifestyle pattern and obesity among young Saudi university students. J Pak Med Assoc 2017;67:1541-6.
102. Alyami MM, Jenkins SC, Hill K. Walking-based activity and sedentary behavior in Saudi males with chronic obstructive pulmonary disease. Saudi Med J 2018;39:506-13.
103. AlQuaiz AM, Siddiqui AR, Kazi A, Batais MA, Al-Hazmi AM. Sedentary lifestyle and Framingham risk scores: A population-based study in Riyadh city, Saudi Arabia. BMC Cardiovasc Disord 2019;19:88.

Supplement II

Table 1: A summary of the studies that assessed daytime cognitive function during Ramadan fasting

Authors	Study population	Assessment tool	Findings	Study details
Bahammam	56 healthy medical students	ESS	Increase in daytime sleepiness	Subjective assessment Assessment was conducted in a nonconstrained environment
Taoudi Benchekroun *et al.*[2]	264 young subjects	ESS	Increase in daytime sleepiness	Subjective assessment Assessment was conducted in a nonconstrained environment
Bahammam[3]	101 healthy fasting and nonfasting subjects	ESS	No change in daytime sleepiness	Subjective assessment Assessment was conducted in a nonconstrained environment
Margolis and Reed[4]	109 healthy medical students	ESS	No change in daytime sleepiness	Subjective assessment Assessment was conducted in a nonconstrained environment
Roky *et al.*[5]	10 healthy young subjects	Visual analog scale MRT CCF at 6 different times of the day: 09.00, 11.00, 13.00, 16.00, 20.00, and 23.00 h	Decreased daytime alertness MRT increased at beginning of Ramadan CCF did not change	Controlled for sleep/wake pattern Compared with baseline, volunteers slept 1 h less during Ramadan Controlled for meal composition and physical activity
Bahammam *et al.*[6]	16 fasting and nonfasting	JDS to assess sleepiness Visual reaction time test ESS	No decrease in alertness No change in daytime sleepiness	Assessed sleep duration objectively using SenseWear Pro Armband™. There was a significant reduction in sleep duration during Ramadan in the fasting group Assessment was conducted in a nonconstrained environment
Bahammam *et al.*[7]	8 healthy young male subjects	JDS Infrared reflectance for blink total duration and a visual reaction time test	No decrease in alertness	Controlled for sleep/wake schedule, sleep duration, caloric intake, energy expenditure, and light exposure Actigraphy to assure adequate sleep duration in days before the study
Chamari *et al.*[8]	11 healthy trained cyclists	CANTAB, RTI and RVP tests	No decrease in alertness RTI was not affected by Ramadan intermittent fasting or time of day Overall, RVP accuracy increased in Ramadan and post-Ramadan compared with baseline; in the last week of Ramadan, accuracy was higher at the end of the day	Sleep duration was not assessed during the 24 h Tests were conducted at different times during and out of Ramadan
Roky *et al.*[9]	8 healthy young subjects	Portable MSLT Visual analog scale	Increase in daytime sleepiness Subjective alertness decreased on day 11 at 12:00 of Ramadan but did not change on day 25 On MSLT, there was a decrease in sleep latency on day 11 and day 25 of Ramadan	Portable device used; programmed to end test after 20 min of recording Sleep duration was significantly lower during Ramadan Meals during baseline and Ramadan were according to a fixed schedule and composition Did not rule out possible sleep deprivation in nights before study

Contd...

Table 1: Contd...

Authors	Study population	Assessment tool	Findings	Study details
Bahammam[10]	8 healthy young subjects	ESS and standard MSLT	No change in daytime sleepiness	Did not rule out possible sleep deprivation in nights before study MSLT was preceded by an overnight in laboratory PSG
Bahammam *et al.*[11]	8 healthy young subjects	ESS and standard MSLT Actigraphy to assess sleep duration in days prior to the study	No change in daytime sleepiness during Islamic intermittent fasting	Sleepiness was assessed while the volunteers were performing intermittent fasting during and outside Ramadan Controlled for sleep duration in nights prior to study and when at home by objective measurements (actigraphy)
Tian *et al.*[12]	18 male athletes	Computerized neuropsychological testing	Performance in functions requiring sustained rapid responses was better in the morning and declined in the late afternoon Performance in nonspeed-dependent accuracy measures was more resilient	Standardized meals were provided Participants' lifestyle and training in between test sessions were not controlled for Sleep duration was significantly shorter during Ramadan Previous night's sleep and daytime naps, as well as the time of awakening, were not controlled for in this study Participants answered questionnaires regarding diet and sleep duration in the previous 24 h

ESS=Epworth Sleepiness Scale, MRT=Movement reaction time, CCF=Critical flicker fusion, CANTAB=Cambridge Neuropsychological Test Automated Battery, RTI=Reaction Time Index, RVP=Rapid visual information processing; JDS=John Drowsiness Scale, IR=Infrared reflectance, MSLT=Multiple sleep latency test, PSG=Polysomnography

Table 2: A summary of the studies that objectively assessed changes in the circadian pattern of body temperature during diurnal intermittent fasting for Ramadan

Authors	Study population	Study design	Assessment tool	Study setting	Findings	Study details
Roky *et al.*[13]	8 healthy young adults (20-28 years old) Location: Morocco	Case cross-over study with repeated measures	Rectal thermistor probe for at least 24 h	Monitoring at home Controlled for meal composition and time, as well as bedtime and rising time	Delay in acrophase and bathyphase	The participants were of the intermediate chronotype as determined by the morningness-eveningness questionnaire Dinner was served 1 h before bedtime during Ramadan and 3 h before bedtime at baseline No objective assessment of prior sleep pattern
Roky *et al.*[5]	10 healthy young adults (20-28 years old) Location: Morocco	Case cross-over study with repeated measures	High-precision medical oral thermometer at 09:00, 11:00, 13:00, 16:00, 20:00, and 23:00	Monitoring at home Controlled for meal composition and time, and bed and rise time	Reversal of circadian pattern of temperature	Subjects were of the intermediate chronotype as determined by the morningness-eveningness questionnaire Sleep duration was 1 h shorter during Ramadan than at baseline No objective assessment of prior sleep pattern
Bahammam[10]	8 healthy young adults (age: 31.8±2 years) Location; Saudi Arabia	Case cross-over study with repeated measures	High-precision medical oral thermometer at 08:00, 16:00, and 00:00	Monitoring in the laboratory Controlled for meal composition	No change	No objective assessment of prior sleep pattern Subjects stayed in the laboratory during monitoring
Bahammam *et al.*[14]	6 healthy young adults with DSPD (18-24 years old) Location; Saudi Arabia	Case cross-over study with repeated measures	SenseWear Pro Armband™ that measures proximal skin temperature during the last week of Shaban and the first 2 weeks of Ramadan	Free-living environment	Further delay in temperature acrophase	Subjects belonged to the evening chronotype Sleep patterns were monitored for 2 weeks before the study by use of sleep diaries (no objective assessment) Sleep/wake schedule and sleep duration during the study were assessed objectively via Armband Participants lived in an unconstrained environment during the study

DSPD=Delayed sleep phase disorder

Table 3: A summary of the studies that objectively assessed changes in melatonin during diurnal intermittent fasting for Ramadan

Authors	Study population	Study design	Assessment tool	Study setting	Findings	Study details
Bogdan *et al.*[15]	10 healthy male volunteers (32-40 years old) Location: France	Case cross-over study with repeated measures	Blood samples were obtained every 4 h, omitting the 02:00 time point, before and on the 23rd day of Ramadan	Free-living environment Controlled for meal timing and composition Did not control for light exposure, sleep schedule, or social habits that accompany Ramadan	A decreased and delayed night peak and a flattened slope of serum melatonin concentration in Ramadan	Volunteers slept 1 h less during Ramadan than before Ramadan Melatonin concentrations were not measured late at night, which fails to address the possibility of a late peak in melatonin concentration
Bahammam[10]	8 healthy young adults (age: 31.8±2 years) Location: Saudi Arabia	Case cross-over study with repeated measures	Saliva samples were collected at three time points over a 24-h period (08:00, 16:00, and 00:00) before and on the 7th and 21st days of Ramadan	In-laboratory monitoring Controlled for meal timing and composition Controlled for sleep duration Did not control for light exposure or social habits that accompany Ramadan	A significant decrease in melatonin concentrations at 00:00 and 16:00 during Ramadan. Melatonin profiles continued to show the same trend during Ramadan, but with a flatter slope	Melatonin concentrations were not measured late at night, which fails to address the possibility of a late peak in melatonin concentration
Almeneessier *et al.*[16]	8 healthy young adults (a mean age of 26.6±4.9) Location: Saudi Arabia	Case cross-over study with repeated measures	Blood samples were collected at 22:00, 02:00, 04:00, 06:00, and 11:00 before Ramadan and while performing fasting outside Ramadan month and on the 2nd week of Ramadan	In-laboratory monitoring Controlled for light exposure, sleep schedule, sleep duration, energy expenditure, and meal composition	Intermittent fasting during Ramadan has no significant effects on the circadian pattern of melatonin	Assessed melatonin level when volunteers were fasting outside Ramadan month to control for lifestyle changes that accompany Ramadan

Table 4: A summary of the studies that assessed sleep architecture using polysomnography during diurnal intermittent fasting for Ramadan

Authors	Study population	Study design	Test used for assessment	Study details	Findings
Roky *et al.*[13]	8 young healthy adults (20-28 years old) Location: Morocco	Case cross-over study with repeated measures	Ambulatory 8-channel unattended PSG	Unattended PSG Dinner was served at 22:30, and PSG recording started at 23:30 Did not objectively account for the prior sleep sleep/wake pattern before assessing sleep Did not monitor for daytime naps before overnight sleep study Meals during and outside Ramadan were according to a fixed schedule and composition	Significant increase in sleep latency and reduction in total sleep time Increase in stage N2 and reduction in slow-wave sleep Reduced REM sleep
Bahammam[10]	8 young healthy adults (age: 31.8±2 years) Location: Saudi Arabia	Case cross-over study with repeated measures	Full attended level 1 in-laboratory PSG	Controlled for sleep schedule, naps, and caloric intake Did not objectively account for the prior sleep/wake pattern before assessing sleep in the laboratory	Significant drop in sleep latency at the end of Ramadan, with no change in total sleep time Reduced REM sleep at the end of Ramadan No significant changes in NREM sleep
Bahammam *et al.*[11]	8 young healthy adults (a mean age of 26.6±4.9 years) Location: Saudi Arabia	Case cross-over study with repeated measures	Full attended level 1 in-laboratory PSG	Controlled for sleep schedule, naps, light exposure, caloric intake, and energy expenditure Assessed the effect of fasting during and outside Ramadan Controlled for sleep/wake and naps for 2 weeks before assessing sleep in the laboratory via actigraphy	Reduced REM sleep during intermittent fasting (during and outside Ramadan) No significant changes in NREM sleep No differences in sleep latency, arousal index, or sleep efficiency
Chamari *et al.*[8]	11 young healthy trained cyclists (a mean age of 21.6±4.8 years) Location: Qatar	Case cross-over study with repeated measures	Portable PSG	Unattended PSG Did not control for sleep/wake pattern or sleep duration During Ramadan, volunteers slept during daytime and at night before and after Ramadan During Ramadan, the volunteers slept in the morning after eating a main meal Naps were not controlled for Did not account for the prior sleep/wake pattern before assessing sleep Participants were cyclists at a training camp The portable device used in the study had relative weakness at the level of the number of awakenings Data regarding sleep duration were highly heterogeneous	No change in sleep duration Significant increases in the number of awakenings and light sleep in Ramadan Progressive decrease in duration of deep and REM sleep stages that became significant 2 weeks after Ramadan

NREM=Nonrapid eye movement sleep, REM=Rapid eye movement sleep, PSG=Polysomnography

Table 5: A summary of the studies that assessed daytime sleepiness and daytime alertness during diurnal intermittent fasting for Ramadan

Authors	Study population	Study design	Assessment tool	Findings	Study details
Subjective assessment					
Bahammam[1]	56 healthy medical students (a mean age of 22.6±1.3 years) Saudi Arabia	Case cross-over study with repeated measures	ESS	Increase in daytime sleepiness	Subjective assessment Assessment was conducted in an unconstrained environment
Taoudi Benchekroun *et al.*[2]	264 young subjects (20-30 years) Location: Morocco	Case cross-over study with repeated measures	ESS	Increase in daytime sleepiness	Subjective assessment Assessment was conducted in an unconstrained, free-living environment
Bahammam[3]	101 healthy fasting and nonfasting subjects (a mean age of 31.3±2.1) Location: Saudi Arabia	Case-control study with repeated measures	ESS	No change in daytime sleepiness	Subjective assessment Assessment was conducted in an unconstrained, free-living environment
Margolis and Reed[4]	109 healthy medical students (19-23 years old) Location: United Arab Emirates	Case cross-over study with repeated measures	ESS	No change in daytime sleepiness	Subjective assessment Assessment was conducted in an unconstrained, free-living environment
Nugraha *et al.*[17]	Among young healthy adults Fasting group (*n*=25) (age: 26.12±0.98 years); nonfasting group (*n*=25) (age: 26.2±0.98 years) Location: Germany	Case-control with repeated measures	ESS	No difference in daytime sleepiness between the two groups. However, the ESS score among the fasting group was significantly lower in the last week of Ramadan than in the 1st week	Subjective assessment Assessment was conducted in an unconstrained, free-living environment
Objective assessment					
Roky *et al.*[5]	10 healthy young subjects (20-28 years old) Location: Morocco	Case cross-over study with repeated measures	Visual Analogue Scale MRT CFF All measurements taken at 6 different times of the day: 09:00, 11:00, 13:00, 16:00, 20:00, and 23:00	Decreased daytime alertness MRT increased at the beginning of Ramadan CFF did not change	Controlled for sleep/wake pattern Volunteers slept 1 h less during Ramadan than at baseline Controlled for meal composition and physical activity
Bahammam *et al.*[6]	16 fasting and non-fasting subjects 8 fasting (mean age: 36.25±4.46 years) 8 nonfasting (mean age: 34.75±3.33 years) Location: Saudi Arabia	Case-control with repeated measures	Johns Drowsiness Scale to assess sleepiness Visual reaction time test ESS	No decrease in alertness No change in daytime sleepiness	Assessed sleep duration objectively using the SenseWear Pro Armband™. There was a significant reduction in sleep duration during Ramadan in the fasting group Assessment was conducted in an unconstrained environment
Bahammam *et al.*[7]	8 healthy young male subjects (a mean age of 25.3±2.9 years) Location: Saudi Arabia	Case cross-over study with repeated measures	Johns Drowsiness Scale Infrared reflectance for total blink duration and a visual reaction time test	No decrease in alertness	Controlled for sleep/wake schedule, sleep duration, caloric intake, energy expenditure, and light exposure Actigraphy to assure adequate sleep duration in days before the study

Contd...

Table 5: Contd...

Authors	Study population	Study design	Assessment tool	Findings	Study details
Chamari *et al.*[8]	11 young healthy trained cyclists (a mean age of 21.6±4.8 years) Location: Qatar	Case cross-over study with repeated measures	CANTAB, RTI, and RVP tests	No decrease in alertness RTI was not affected by Ramadan intermittent fasting or time of day Overall, RVP accuracy increased during and after Ramadan compared with baseline; in the last week of Ramadan, accuracy was highest at the end of the day	Sleep duration was not assessed during the 24 h Tests were conducted at different times during and outside Ramadan
Roky *et al.*[9]	8 healthy young subjects (20-28 years old) Location: Morocco	Case cross-over study with repeated measures	Portable MSLT Visual analogue scale	Increase in daytime sleepiness Subjective alertness decreased at 12:00 on day 11 of Ramadan but did not change on day 25 On the MSLT, sleep latency was decreased on day 11 and day 25 of Ramadan	Portable device used; programmed to end test after 20 min of recording Sleep duration was significantly lower during Ramadan than at baseline Meals during baseline and Ramadan followed a fixed schedule and composition Did not rule out possible sleep deprivation in nights before study
Bahammam[10]	8 healthy young subjects (age: 31.8±2 years) Location: Saudi Arabia	Case cross-over study with repeated measures	ESS and standard MSLT	No change in daytime sleepiness	Did not rule out possible sleep deprivation in nights prior to study MSLT was preceded by an overnight in-laboratory PSG
Bahammam *et al.*[11]	8 healthy young subjects (a mean age of 26.6±4.9 years) Location: Saudi Arabia	Case cross-over study with repeated measures	ESS and standard MSLT Actigraphy to assess sleep duration in days before the study	No change in daytime sleepiness during Islamic intermittent fasting	Sleepiness was assessed while the volunteers were performing intermittent fasting during and outside Ramadan Controlled for sleep duration in nights before study and when at home by objective measurements (actigraphy)
Tian *et al.*[12]	18 male athletes (17-29 years old) Location: Singapore	Case cross-over study with repeated measures	Computerized neuropsychological testing	Performance in functions requiring sustained rapid responses was best in the morning and declined in the late afternoon Performance in nonspeed-dependent accuracy measures was more resilient	Standardized meals were provided Participants' lifestyle and training in between test sessions were not controlled for sleep duration was significantly shorter during Ramadan than at baseline Previous night's sleep and daytime naps, as well as the time of awakening, were not controlled for in this study Participants answered questionnaires regarding diet and sleep duration in the previous 24 h

MRT=Movement reaction time, CFF=Critical flicker fusion, ESS=Epworth Sleepiness Scale, CANTAB=Cambridge Neuropsychological Test Automated Battery, RTI=Reaction Time Index, RVP=Rapid Visual Information Processing, JDS=John Drowsiness Scale, IR=infrared reflectance, MSLT=Multiple sleep latency test, PSG=Polysomnography

References

1. Bahammam A. Does Ramadan fasting affect sleep? Int J Clin Pract 2006;60:1631-7.
2. Taoudi Benchekroun M, Roky R, Toufiq J, Benaji B, Hakkou F. Epidemiological study: Chronotype and daytime sleepiness before and during Ramadan. Therapie 1999;54:567-72.
3. BaHammam A. Assessment of sleep patterns, daytime sleepiness, and chronotype during Ramadan in fasting and nonfasting individuals. Saudi Med J 2005;26:616-22.
4. Margolis SA, Reed RL. Effect of religious practices of Ramadan on sleep and perceived sleepiness of medical students. Teach Learn Med 2004;16:145-9.
5. Roky R, Iraki L, HajKhlifa R, Lakhdar Ghazal N, Hakkou F. Daytime alertness, mood, psychomotor performances, and oral temperature during Ramadan intermittent fasting. Ann Nutr Metab 2000;44:101-7.
6. Bahammam AS, Alaseem AM, Alzakri AA, Sharif MM. The effects of Ramadan fasting on sleep patterns and daytime sleepiness: An objective assessment. J Res Med Sci 2013;18:127-31.
7. Bahammam AS, Nashwan S, Hammad O, Sharif MM, Pandi-Perumal SR. Objective assessment of drowsiness and reaction time during intermittent Ramadan fasting in young men: A case-crossover study. Behav Brain Funct 2013;9:32.
8. Chamari K, Briki W, Farooq A, Patrick T, Belfekih T, Herrera CP. Impact of Ramadan intermittent fasting on cognitive function in trained cyclists: A pilot study. Biol Sport 2016;33:49-56.
9. Roky R, Chapotot F, Benchekroun MT, Benaji B, Hakkou F, Elkhalifi H, *et al*. Daytime sleepiness during Ramadan intermittent fasting: Polysomnographic and quantitative waking EEG study. J Sleep Res 2003;12:95-101.
10. BaHammam A. Effect of fasting during Ramadan on sleep architecture, daytime sleepiness and sleep pattern. Sleep Biol Rhythm 2004;2:135-43.
11. Bahammam AS, Almushailhi K, Pandi-Perumal SR, Sharif MM. Intermittent fasting during Ramadan: Does it affect sleep? J Sleep Res 2014;23:35-43.
12. Tian HH, Aziz AR, Png W, Wahid MF, Yeo D, Constance Png AL. Effects of fasting during Ramadan month on cognitive function in Muslim athletes. Asian J Sports Med 2011;2:145-53.
13. Roky R, Chapotot F, Hakkou F, Benchekroun MT, Buguet A. Sleep during Ramadan intermittent fasting. J Sleep Res 2001;10:319-27.
14. BaHammam A, Alrajeh M, Albabtain M, Bahammam S, Sharif M. Circadian pattern of sleep, energy expenditure, and body temperature of young healthy men during the intermittent fasting of Ramadan. Appetite 2010;54:426-9.
15. Bogdan A, Bouchareb B, Touitou Y. Ramadan fasting alters endocrine and neuroendocrine circadian patterns. Meal-time as a synchronizer in humans? Life Sci 2001;68:1607-15.
16. Almeneessier AS, Bahammam AS, Sharif MM, Bahammam SA, Nashwan SZ, Pandi Perumal SR, *et al*. The influence of intermittent fasting on the circadian pattern of melatonin while controlling for caloric intake, energy expenditure, light exposure, and sleep schedules: A preliminary report. Ann Thorac Med 2017;12:183-90.
17. Nugraha B, Ghashang SK, Hamdan I, Gutenbrunner C. Effect of Ramadan fasting on fatigue, mood, sleepiness, and health-related quality of life of healthy young men in summer time in Germany: A prospective controlled study. Appetite 2017;111:38-45.

Supplement III

The organizing committee would like to thank all the experts who participated in voting in rounds 1 and 2 and approved the final draft of the recommendations.

Sleep Duration Committee

Prof. Siraj Wali
Pulmonary and Sleep Medicine, King Abdulaziz University, Jeddah

Prof. Muslim Mohammed Alsaadi
Pediatric Sleep Medicine, College of Medicine, King Saud University, Riyadh

Prof. Hamdan Al-Jahdali
Pulmonary and Sleep Disorders, King Abdelaziz Medical Center, Riyadh

Prof. Adel Alharbi
Pediatrician, Pulmonary and Sleep Medicine , Prince Sultan Military Medical City, Riyadh

Dr. Mouhamd Ghyath Jamil
Pulmonary, Critical Care and Sleep Medicine, King Faisal Hospital & Research Center, Riyadh

Dr. Wadha Helal Alotaibi
Pediatric Pulmonary and Sleep Medicine, King Fahad Medical City, Riyadh

Dr. Aljohara Almeneessier
Family Medicine, King Saud University, Riyadh

Dr. Sultan Alshahrani
Psychiatrist and Sleep Medicine, King Abdullah bin Abdulaziz University Hospital/Princess Norah University, Riyadh

Dr. Abdullah Alshamrani
Pediatric Sleep Medicine, Prince Sultan Military Medical City, Riyadh

Dr. Muhannad Hawari
Pulmonary and Sleep Medicine, King Faisal Hospital & Research Center, Riyadh

Dr. Abdullah Khayat
Pediatric Pulmonary and Sleep Medicine, Taif University, Taif

Dr. Ahmed Almutairi
Adult Pulmonary and Sleep Medicine, King Abdulaziz Medical City, Riyadh

Dr. Mohammed Albalawi
Pediatric Pulmonary and Sleep Medicine, King Faisal Specialist Hospital & Research Center, Riyadh

Dr. Ranya Alshumrani
Pediatric Pulmonary and Sleep Medicine, King Abdulaziz University Hospital, Jeddah

Dr. Riyad Omar Allehebi
Pulmonary and Sleep Medicine, King Fahad Medical City, Riyadh

Dr. Fawaz Alharbi
Sleep Medicine, Prince Sultan Military Medical City, Riyadh

Dr. Sultan Ali Qanash
Pulmonary and Sleep Medicine, King Abdulaziz Medical City, Jeddah

Dr. Fayez Almutairi
Pulmonary and Sleep Medicine, King Abdelaziz National Guard Hospital, Alhasa

Dr. Ahmad Mansoor Aldobyany
Pulmonary and Sleep Medicine, King Abdullah Medical City, Makkah

Dr. Yousef Alqurashi
Respiratory and Sleep Medicine, Imam Abdulrahman bin Faisal University/King Fahad University Hospital, Dammam

Dr. Meteb Hamid Alenazi
Psychiatry and Sleep Medicine, King Saud University, Riyadh

Dr. Saad Alshareef
Pulmonary and Sleep Medicine, Al-Imam University, Riyadh

Dr. Shaden Qasrawi
Pulmonary and Sleep Medicine, Kingdom Hospital, Riyadh

Dr. Noor Adnan Almodihesh
Child and Adolescence Psychiatry, King Saud University & Medical City, Riyadh

Dr. Salih Aleissi
Sleep Medicine, King Saud University and Medical City, Riyadh

Dr. Mana Mubarak Alshahrani
Family Medicine and Sleep Medicine, King Faisal Medical City, Abha

Dr. Afnan Adel Shukr
Pulmonary and Sleep Medicine, King Abdullah Medical Complex, Jeddah

Dr. Mashni Alsaeed
Sleep Technology and Behavioral Sleep Medicine, King Faisal Specialist Hospital, Jeddah

Mr. Mohammed Alhasson
Pulmonary and Sleep Medicine, King Fahad Specialist Hospital, Qassim

Dr. Ali Abdulmana Awadh
Family Medicine, University Sleep Disorders Center, Riyadh

Dr. Areej Ayedh Alharthi
Neurology, King Khalid University Hospital, Riyadh,

Physical Activity and Sedentary Behavior Committee

Prof. Khalid Saleh Almuzaini
Exercise Physiology, King Saud University, Riyadh

Dr. Shaea Ayed Alkahtani
Exercise Physiology & Energy Metabolism, King Saud University, Riyadh

Dr. Mohammad Ali Alahmadi
Exercise Physiology, Taibah University, Madinah

Dr. Abdulazeem Alotaibi
Exercise Physiology, Qassim University, Qassim

Dr. Faisal Awad Barwais
Exercise Physiology, Umm Al-Qura University, Makkah

Dr. Anwar Abdulaziz Alnuaim
Physical Activity & Public health, King Faisal University, Alhasa

Dr. Mohammed Shuaib Alibrahim
Movement Science, King Faisal University, Riyadh

Dr. Huda Ahmad Alaamer
Nutrition & Food Science, Princess Nourah bint Abdulrahman University, Riyadh

Dr. Baraa Sami Quronfulah
Health Promotion, Umm Al-Qura University, Makkah

Dr. Aqeel Mohammed Alenazi
Physiotherapy & Rehabilitation, Prince Sattam bin Abdulaziz University, Wadi Ad-dawasir