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Wearable Artificial Intelligence for Assessing Physical Activity in High School Children

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Abstract: Eighty one percent of adolescents aged 11–17 years are inadequately physically active worldwide. Physical activity (PA) recommendations for high school children have not been studied previously in schools in the Qatar region. The objectives of the study were: (i) to assess the level of compliance of the recommended PA and to assess if there are any gender differences; and (ii) to analyze the recommended step count compliance during school and non-school days. An observational cross-sectional study was conducted. Twenty-nine children (12 boys and 17 girls) aged 13–17 years (15.24 ± 1.46) took part in this study. Participants wore Fitbit Charge 5 wrist bands for three weeks to collect various digital biomarkers including moderate-to-vigorous physical activity (MVPA) and step counts (tracking during out-of-school time and school time). Based on this study, high school children in the two Qatar region schools did not meet the MVPA and steps/day recommendation by the established agencies: 38% of the total study group met the recommended 60 min/day of activity (50% boys, 29% girls). Gender differences were also observed in PA levels and steps per day: for non-school days, 17% met the recommended 10,000 steps/day (25% boys, 12% girls). There was a pattern of greater PA performance and steps during the weekdays as opposed to the weekend, but these values showed no robust evidence in favor of H1 or statistical significance for step counts. However, the evidence was robust in favor of H1 (difference between weekend and weekday) due to a statistically significant difference for meeting the 60 min/day activity. While further studies are required to establish if this is a general trend in Qatari schools, this pilot study does highlight the need to design more effective programs and messaging strategies to improve PA levels in the high school population.

Keywords: children; adolescents; physical activity; exercise; wearable devices; fitness trackers; Fitbit; Qatar

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1. Introduction

Promoting good health and well-being is one of the major sustainable development goals of the United Nations for 2030. Regular physical activity (PA) has been shown to enhance wellness and reduce the risk of non-communicable diseases (NCDs) and chronic health conditions such as obesity and diabetes, coronary heart disease, and possibly delay the onset of Alzheimer's disease [1–4]. Everyone, regardless of age, gender, race, ethnicity, or current fitness level, may benefit from moving more and sitting less. Childhood and adolescence are key years for acquiring movement abilities, forming healthy habits, and

laying the groundwork for lifetime health and well-being. PA enhances health and fitness in children and teenagers [5,6].

Established health agencies agree that school aged children should engage in around 60 min of PA daily. The Center for Disease Control and Prevention and U.S. Guidelines recommend that children aged 6–17 perform at least 60 min of moderate-to-vigorous physical activity (MVPA) daily and a minimum of three days of vigorous physical activity weekly (VPA) [7,8]. Similarly, in the UK (5–18 years) and EU (school aged youth) guidelines recommend that children and young people engage in MVPA for at least 60 min daily [9,10]. Canada [11] and Australia [12] offer similar recommendations in line with the World Health Organization (WHO) guidelines [2]. Studies have also evaluated PA in step counts, with recent cross-validation study recommendations outlining that a cutoff point of 10,000 steps daily seems to be the most appropriate for adolescents [13].

Evidence suggests that global PA levels have declined [14,15]. Only 19% of adolescents aged 11–17 years are adequately physically active worldwide, with considerable disparities among genders, regions, and nations [16]. Physically active youth exhibit greater levels of cardiorespiratory fitness and stronger muscles than idle youth. They also have less body fat and stronger bones. PA also boosts cognition and lessens symptoms of depression in school-aged children. Evidence suggests that both acute bouts of MVPA and regular MVPA improve children's cognitive skills of memory, executive function, processing speed, attention, and academic achievement [17].

Most children spend approximately one-third of the day at school, making school an ideal place to encourage PA from an early age using known daily recommendations to implement PA programs and study PA levels [18,19]. Research examining PA behavior at various times of the day shows that around half of the necessary daily MVPA time should occur during "school time" [20,21]. However, evidence suggests that children actually have a higher level of PA "out-of-school time" than "school time" [22]. Some regions have successfully increased the PA levels in line with the recommendations by introducing a walking school bus for commuting to and from school [23,24]. However, in a country like Qatar where temperatures can soar beyond 45 degrees Celsius, this is not a viable option except during a select few winter months.

Commercially available wearable devices (WDs) such as smart watches and smart bands can monitor a person's vital health stats including heart rate (using a photoplethysmography sensor), activity (using accelerometer sensor), and sleep (using a combination of sensors). WDs normally depend on Artificial Intelligence (AI) to assess such biomarkers. Specifically, AI digests data collected by the sensors using sophisticated and personalized analytics to measure biomarkers, thereby providing valuable insights. Given that many commercially available WDs keep their algorithms proprietary, their accuracy in assessing biomarkers varies. Using AI on accelerometer data have proven highly accurate in calculating step counts [25]. When worn on the torso during self-paced walking, studies have shown that Fitbit devices are most likely to deliver accurate measurements of steps in people with no mobility impairments [26–29]. The latter study also concluded that Fitbit activity trackers require further accuracy studies when it comes to sleep and distance, as limited evidence suggests that Fitbits may not provide accurate measures for these measures. Nevertheless, such studies highlight that Fitbit devices outstrip competitors in the collection and accuracy of wearable data.

Recently, WDs have increased in popularity due to their fashionable and affordable nature, and when used properly, they can change their lifestyle habits. Although the technology has existed for some time in devices such as smart phones, WDs are ideal for monitoring PA in school children because of their portability [30]. Their ability to collect data quickly and efficiently has contributed to their widespread use in the scientific literature [31,32].

Recent studies have used smart devices to analyze the PA levels for early age children [30], but there is a lack of robust studies for the high school age group in the Qatar region. According to this study's hypotheses, adolescents may differ in their daily step

count and PA level based on their gender and the time of day they perform PA. Considering this, this study examined the high school students' adherence to daily PA guidelines for gender as well as PA over various time periods (Sunday to Thursday, which is the working week in Qatar, versus weekend and school-time versus out-of-school time). Although multiple studies suggest the advantages of PA in children, few studies have been conducted on high school children within the Arab population, more specifically within Qatar.

2. Materials and Methods

2.1. Design

We conducted an observational, cross-sectional study to assess PA among high school children at various times of the day. Data were collected in the same population at one given time point (three consecutive weeks during school time). Twenty-nine healthy adolescents, aged 13 to 17, from two private high schools in Doha, were recruited for this study.

2.2. Subjects

We originally gained consent from and released devices to 39 participants; after dropouts, we remained with a final recruitment of 29 adolescents from two local high schools in Doha (Qatar). Reasons for dropout included: not synchronizing with the mobile application (app), not wearing the WD at all, and not wearing the WD often enough to acquire meaningful data. The mean age of the participants was 15.24 (SD 1.46). The sample included 12 boys and 17 girls. While boys had a mean weight of 71.76 kg (±18.05) and mean height of 170.88 cm (±9.57), the girls had a mean weight of 54.37 kg (±13.16) and mean height of 158.26 kg (±6.02). The inclusion criteria in this study were as follows: children with good general health and of high school age (11–17 years); without any known skin allergy due to material from the device sensor; and must have a smart mobile phone for connecting to a device along with Internet accessibility. The study followed the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB), Weill Cornell Medicine-Qatar (WCM-Q, Study No.: 21-00025). Written assent was obtained from all the participants and written informed consent was obtained from all the participants' parents.

2.3. Procedure and Measures

Participants were recruited by the schools if they expressed an interest in volunteering for the study. Participants wore a Fitbit Charge 5 wrist band [33] and were asked to keep the device on any wrist for the duration of the study including sleep times, but were allowed to take it off for charging or other short periods of time if required. The devices were worn consecutively for the duration of the study (20 days). The devices were setup and introduced to the children by the WCM-Q research staff in class school time, and clear verbal and written instructions were given on how to pair the Fitbit band with the Fitbit smartphone app [34,35], which had to be downloaded separately. The app allowed the participants to interact with the Fitbit Charge 5 and control settings. Before releasing the devices, accounts were created for each participant and all the default Fitbit alerts and health reminders were turned off to avoid distraction to the participants.

The study was conducted in March 2022. WCM-Q researchers monitored the data via the System for Integrated Health Analytics (SIHA) application [36], and students were reminded with weekly visits to synchronize the data if the SIHA app showed that no data were present. At the end of the study, data were downloaded onto secure HIPAA compliant WCM-Q servers for further processing. The research collected PA in steps and minutes of MPA, VPA, and MVPA per day. MVPA and steps were averaged as minutes/day (min/day) and steps/day, respectively. The 60 min MVPA rate [2,7,9–12,17] and the 10,000 steps rate [13] were used as reference values for similar aged children as per the guidelines in the literature.

2.4. Statistical Analysis

Initially, we descriptively analyzed the data using the means and standard deviation. The *t*-test was used to test the null hypothesis, the null hypothesis (H0) indicating that the true difference between the two groups had a mean of zero, and the alternative hypothesis (H1) indicating that the true difference is different from zero. To compare groups, a series of inferential statistical tests was performed. The *t*-test was then computed for independent samples to compare gender (boys vs. girls), In addition, the Student's paired samples *t*-test was employed to examine the differences between various moments (midweek vs. weekend and school time vs. out-of-school time), in line with previous similar studies [19,30]. A *p*-value of less than 0.05 was deemed statistically significant.

The analysis was performed using Python programming language version 3.8.10, with packages including NumPy, pandas, skLearn (Scikit-learn), seaborn, and Matplotlib. The tests were executed on a computer running the Windows 11 Pro operating system with Intel(R) processor 11th generation i9 with eight cores @ 2.60GHz and 64 GB RAM.

3. Results

The descriptive values, *p*-values, and effect size used to compare the recommended PA duration in minutes by gender are observed in Table 1. Table 1 outlines that during the "week" (inclusive of weekends and weekdays), 38% of the total study group met the recommended 60 min/day of activity (50% boys, 29% girls). For "school days" during the week (Sunday to Thursday), 34% of the sample met the recommended 60 min/day of MVPA (50% boys, 24% girls). For non-school days (i.e., weekends), 17% of the sample met the recommended 60 min/day of MVPA (25% boys, 12% girls). This highlights the gender differences and indicates a general trend toward higher mean values for boys for almost all of the variables, as more boys met the target MVPA than the girls during both school and non-school days.

Table 2 highlights the step count recommendations met by gender, showing that during the "week" (inclusive of weekends and weekdays), 24% of the total study group met the recommended 10,000 steps/day (25% boys, 24% girls), thus there were no differences based on gender. For "school days" during the week (Sunday to Thursday), again 24% of the participants met the recommended 10,000 steps/day (25% boys, 24% girls), with no differences based on gender. For non-school days (i.e., weekends), 17% met the recommended 10,000 steps/day (25% boys, 12% girls), signifying that approximately more than half of the boys met the step recommendations than girls during the weekends (non-school days). For school days (weekdays), we did not observe the target 10,000 step counts for school timings, therefore reporting was only carried out for the whole school day. For out of school time (i.e., total times be it weekend or weekday), we observed that 14% of the total study group met the recommended 10,000 steps/day (25% boys, 5% girls), showing clear gender-based differences. In general, a higher percentage of total participants met the recommendations during the school days compared to the weekends (34% and 17% respectively).

Table 3 outlines the Student's paired samples t-test, indicating a trend toward higher mean values for meeting the 60 min/day activity in the "weekend" compared to "weekday." The evidence is fairly robust in favor of H1 (difference between weekend and weekday) due to a statistically significant difference indicated by a *p*-value of <0.05(0.0133). The Student's paired sample t-test indicates a trend toward higher mean values for meeting the 10,000 steps/day target on the "weekdays" compared to the "weekend". However, there was no observed robust evidence in favor of H1 (differences between "weekday" and "weekend") or statistically significant differences.

Table 4 shows the Student's paired samples t-test used to observe the PA levels and PA target met recommendation differences between "school time" and "out of school time". Entries are marked as "NAN" (not a number), as there were clearly no targets of 10,000 steps being met at school time only.

Table 1. Participants' characteristics, activity minutes, and meeting recommendations by gender.

Variables	Total (n = 29)	Boys (n = 12)	Girls (n = 17)	F-Value	*p*-Value
Age	15.24 ± 1.45	15.5 ± 1.31	15.05 ± 1.56		
Height (cm)	163.48 ± 9.83	170.88 ± 9.57	158.26 ± 6.02		
Weight (kg)	61.57 ± 17.40	71.76 ± 18.05	54.37 ± 13.16		
BMI	23.24 ± 7.35	23.32 ± 7.02	23.20 ± 7.50		
Weeks MPA * (min/day)	9.69 ± 20.57	15.26 ± 22.72	7.50 ± 19.27	9.124	0.0027 **
Weeks VPA * (min/day)	6.89 ± 16.27	13.94 ± 22.95	4.12 ± 11.67	24.51	1.22×10^{-6} **
Weeks MVPA * (min/day)	16.58 ± 34.73	29.21 ± 43.10	11.61 ± 29.48	16.83	5.23×10^{-5} **
AR Week 60 min/day (%)	105.65 ± 46.79 (37.93%)	101.5 ± 35.64 (50%)	112.45 ± 62.36 (29.41%)	0.37	0.55
Weeks Sunday to Thursday MPA (min/day)	8.93 ± 16.76	14.56 ± 20.93	6.73 ± 14.31	10.47	0.0013 **
Weekends MPA (min/day)	11.87 ± 28.82	17.21 ± 27.54	9.72 ± 29.27	1.11	0.295
Weeks Sunday to Thursday VPA (min/day)	6.824 ± 15.49	14.55 ± 22.96	3.81 ± 9.88	24.40	1.51×10^{-6} **
Weekends VPA (min/day)	7.08 ± 18.42	12.26 ± 23.33	5.0 ± 15.79	2.598	0.111
Sunday to Thursday MVPA (min/day)	15.75 ± 30.22	29.11 ± 41.20	10.54 ± 22.77	18.72	2.26×10^{-5} **
AR Sunday to Thursday MVPA 60 min/day (%)	92.76 ± 35.21 (34.48%)	94.64 ± 31.90 (50%)	89.0 ± 43.63 (23.5%)	0.12	0.738
Weekends MVPA (min/day)	18.96 ± 45.32	29.47 ± 48.99	14.72 ± 43.48	1.75	0.189
AR weekends MVPA 60 min/day (%)	139.5 ± 58.35 (17.24%)	125.5 ± 42.41 (25%)	153.5 ± 75.0 (11.76%)	0.42	0.539

Note: BMI: Body Mass Index Corporal; AR: Accomplishment Recommendations; MVPA: Moderate-to-vigorous Physical Activity; * MPA = Moderate Physical Activity, VPA = Vigorous (Very Active) Physical Activity, ** = *p*-value < 0.05.

Table 2. Participants' characteristics, steps, and meeting recommendations by gender.

Variables	Total	Boys	Girls	F-Value	*p*-Value
Week steps/day	5043.52 ± 4343.37	6750.82 ± 5935.11	4380.42 ± 3325.84	19.79	1.20×10^{-5} **
AR Week 10 K steps/day (%)	13,549.5 ± 2388.89 (24.13%)	14,005.57 ± 2486.40 (25%)	11,953.25 ± 971.82 (23.52%)	5.134	0.029**
Sun to Thurs steps/day	5195.17 ± 4335.67	6831.21 ± 5991.58	4568.18 ± 3315.68	13.28	0.0003**
AR Sun to Thurs 10 K steps/day (%)	13,825.6 ± 2304.92 (24.13%)	14,333.0 ± 2253.64 (25%)	11,796.0 ± 1146.66 (23.53%)	5.819	0.024 **
Weekend steps/day	4605.63 ± 4363.13	6527.08 ± 5901.40	3830.32 ± 3323.50	6.713	0.011 **
AR Weekend 10 K steps/day (%)	12,922.0 ± 2569 (17.24%)	13,187 ± 2998 (25%)	12,215.33 ± 714.87 (11.76%)	0.289	0.603
School Time steps/day	2380.63 ± 2062.73	2905.53 ± 2580.65	2180.21 ± 1795.93	5.75	0.017 **
AR School Time 10 K steps/day (%)	NAN	NAN	NAN	NAN	NAN
Out of School Time steps/day	2877.19 ± 2895.38	3994.81 ± 3970.91	2442.28 ± 2211.29	18.83	1.93×10^{-5} **
AR Out of School Time 10K steps/day (%)	11,239.7 ± 1173.15 (13.79%)	11,193.22 ± 1234.52 (25%)	11,658.0 ± NAN (5%)	0.127	0.730

Note: NAN: Not a Number (no records were retrieved meeting the under-discussion criteria), ** = *p*-value < 0.05.

Figure 1A outlines the descriptive data on the MVPA minutes for students from both schools during the study. We observed a notable pattern by gender, with boys being more physically active than girls. Looking at the distribution of students based on the recommendation criteria of 60 min per day (Figure 1B), boys had a median of 102 PA minutes regardless of the day of the week. Weekdays had the most activity at 90 min per day, whereas on the weekends, boys were less active than girls, with a median of 141 min. Furthermore, during the 20-day study, it was observed that the boys were able to meet the recommended 60 min of PA 20 times (Figure 1C), especially at weekends.

Table 3. Differences in the children's PA between "Monday to Friday" and "Weekend" variables.

Variables	Sunday to Thursday	Weekend	F-Value	*p*-Value
MVPA (min/day)	15.75 ± 30.22	18.96 ± 45.32	0.504	0.478
Steps/day	5195.17 ± 4335.67	4605.63 ± 4363.13	1.095	0.296
Recommendation 60 min/day (%)	92.76 ± 35.21 (34.48%)	139.5 ± 58.35 (17.24%)	7.023	0.0133 **
Recommendation 10 K steps/day (%)	13,825.6 ± 2304.92 (24.13%)	12,922.0 ± 2569 (17.24%)	1.096	0.302

Note: MVPA: Moderate-to-Vigorous Physical Activity, ** = *p*-value < 0.05.

Table 4. Differences in the children's PA between "school time" and "out-of-school time" variables.

Variables	School Time	Out of School Time	F-Value	*p*-Value
Steps/day	2380.63 ± 2062.73	2877.19 ± 2895.38	4.86	0.027 **
Recommendation 10 K steps/day (%)	NAN	11,239.7 ± 1173.15	NAN	NAN

Note: MVPA: Moderate-to-Vigorous Physical Activity; NAN: Not a Number (no records were retrieved meeting the under-discussion criteria), ** = *p*-value < 0.05.

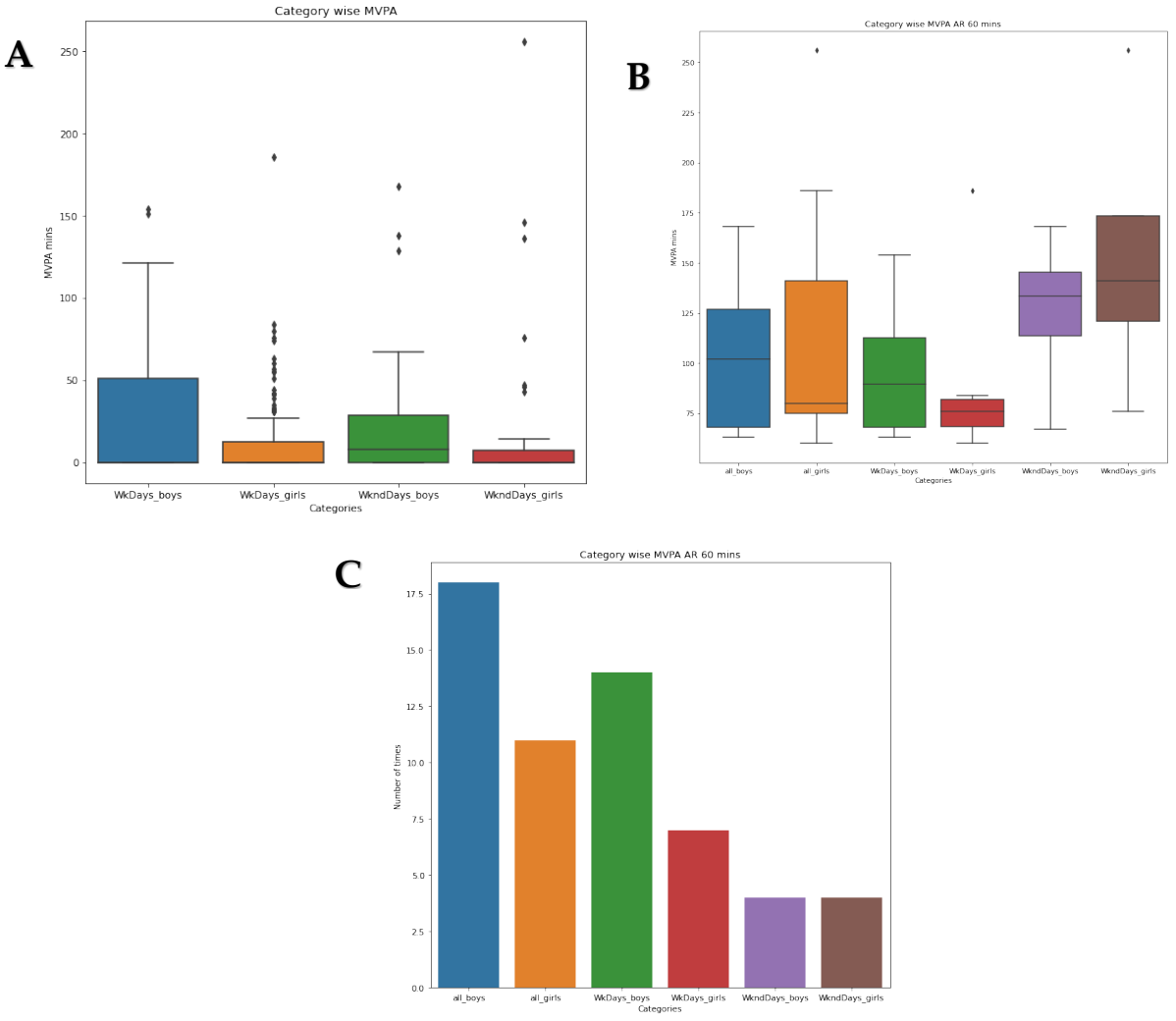

Figure 1. MVPA minutes analysis between different categories. (**A**) MVPA mins for all population by clustering between boys and girls and subclusters into weekday and weekend. (**B**,**C**) represents the participants that met the recommendation of 60 min per day.

We chose to use "step count per day" to estimate the PA among the participants. Boys outperformed girls with a median step count exceeding 5000 on both the weekdays and weekends (Figure 2A). Further investigation revealed that most of the boys were able to meet the recommended threshold of 10,000 steps, completing more than 14,000 steps (mostly at weekdays), and achieved the benchmark 25 times during this study (Figure 2B,C).

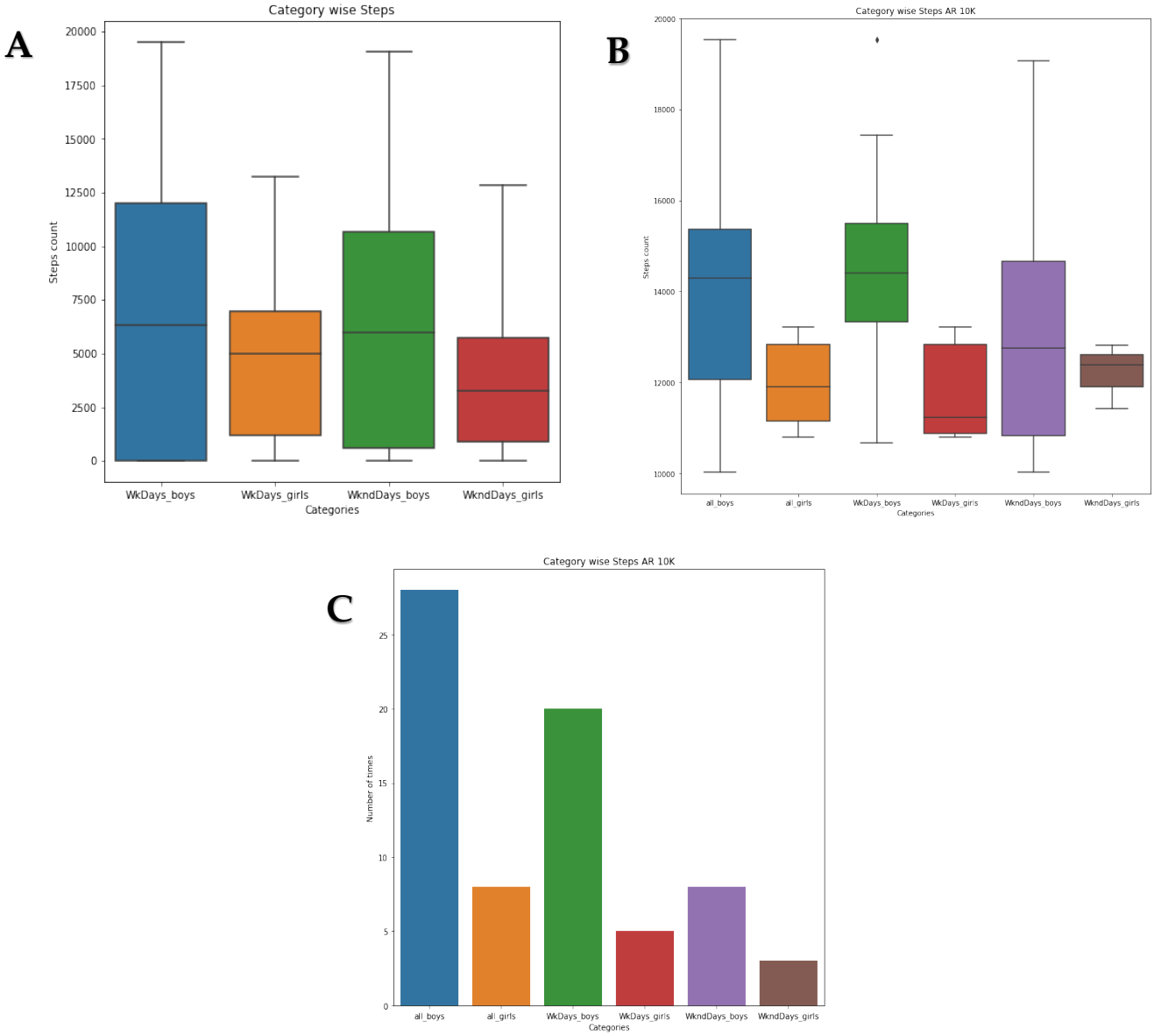

Figure 2. Step count analysis between different categories. (**A**) Step count for all population by clustering between boys and girls and subclusters into weekday and weekend. (**B**,**C**) represents the participants that met the recommendation of 10K steps per day.

Based on week division into weekdays (Sunday to Thursday) and weekends (Friday–Saturday), 75% of the population (Figure 3A) was below 20 min MVPA per day on weekdays (Q3WEEK = 19.5) as well as on the weekends (Q3WEEKEND = 11.5). Amongst the participants that met the target of 60 min per day (Figure 3B), the median was 79 min during the week and 137 min during weekends. An alternative measure of PA step count (Figure 3C) indicated that on weekdays, 75% of the population was below 7.5K (Q3WEEK = 7627) with a median of 5000 steps. On the weekends, 75% of the population was below 6.4K (Q3WEEKEND = 6471.75) with a median of 3500 steps. When considering

only the population who fulfilled the recommended 10,000 steps per day (Figure 3D), the median was 14,000 steps on the weekdays and 12,000 steps on the weekends. Step count analysis (Figure 3E) showed that students were more active outside of school hours, with 75% having steps below 4500 (Q3OutSchool = 4491). Boys outnumbered girls in terms of school timing activity (Figure 3F), with a median of 3400 steps during school and 3100 steps outside of school.

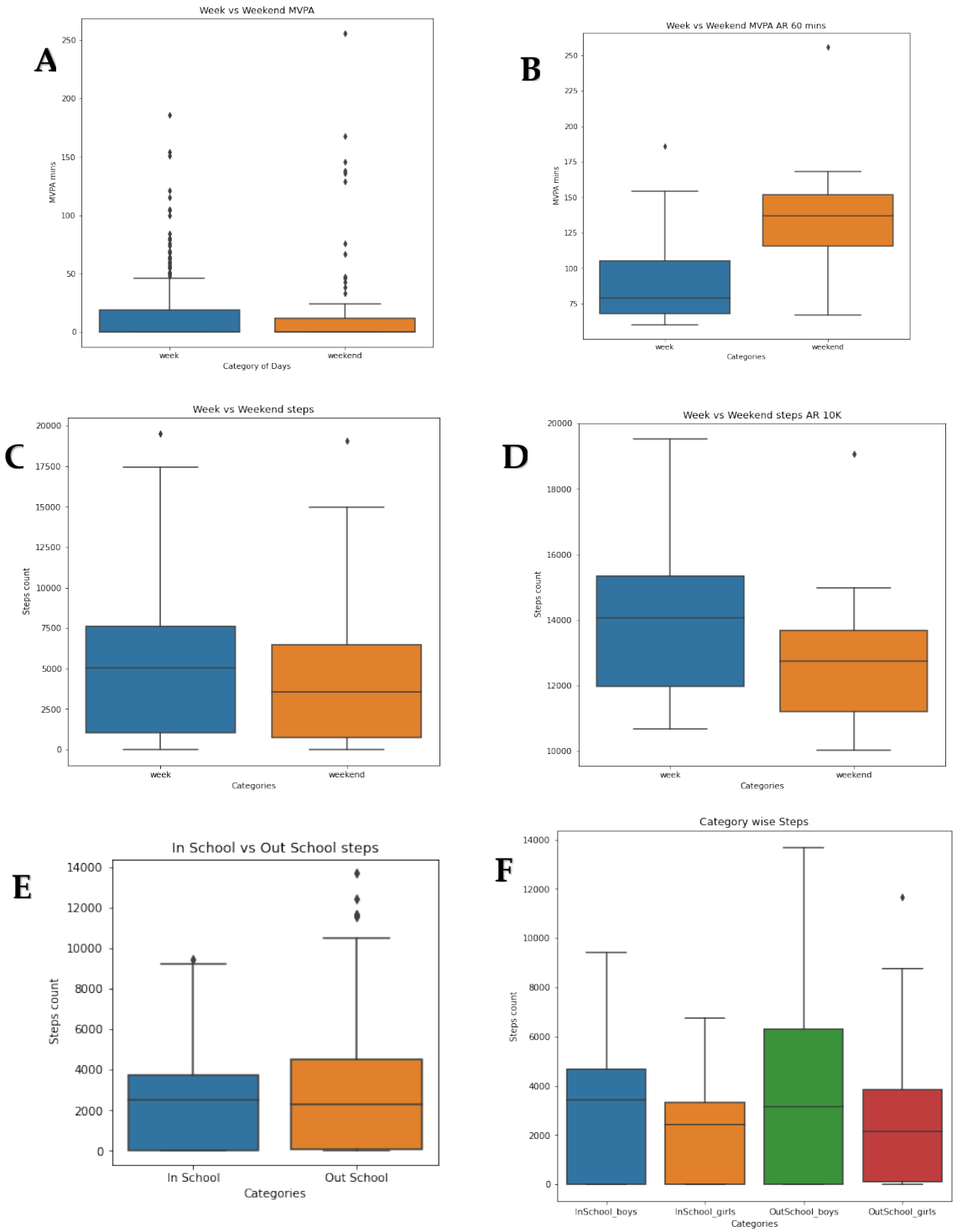

Figure 3. (**A**,**B**) Week vs. weekend analysis of the whole population on the basis of MVPA min. (**C**,**D**) Week vs. Weekend analysis of the whole population on the basis of step count. (**E**,**F**) analysis of step count on the basis of school time and non-school time with gender division.

4. Discussion

Using the guidelines by the established agencies, we evaluated the PA by gender and analyzed periods over 3 weeks during school and non-school days using WDs in healthy high school adolescents in Qatar. Our findings revealed that 38% met the activity recommendations of 60 min/day while 24% met the 10,000 steps/day target. Similar to findings in some previous studies [37–40], where climate seems to have played a role in compliance rates in different age ranges, the lack of outdoor activity due to extreme heat, especially during daylight hours, is a likely contributing factor to the relatively low levels of this statistic in our study.

Using WDs to measure PA enables a step count assessment with little effort from the wearer. We observed 5000 steps/day on average for all participants if we looked at all days. This was considered a low compliance rate (10,000 steps/day according to guidelines), although other studies have shown even lower rates in pre-school populations (approx. 10–15%) [39,41]. Clear gender differences have emerged for six of the variables in Table 1 (weeks MPA, weeks VPA, weeks MVPA, weeks Sun–Thurs MPA, weeks Sun–Thurs VPA, and Sun–Thurs MVPA). With regard to gender, we observed that overall, boys had higher PA values than girls for the recommended 60 min/day PA. For the 10,000 steps/day recommendation, a gender difference was only noted for school time vs. out of school time, and no difference was noted for weekend vs. weekdays. During school days (weekdays), the rate of compliance of MVPA and steps seemed to be higher compared to the weekends. This could suggest that schools are active in promoting PA during school days (though more still needs to be done to meet the target values), or that children are simply more active due to travel to lessons and activity during breaks. An observation during the study by the research team backed up with a random survey in a subsample of both boys and girls seems to suggest that during breaks on school days, girls tended to enjoy chatting with peers and being involved in other social media related activities, while the boys preferred to participate in sports requiring enhanced physical activity.

This study highlights that high school children from the participating schools in Qatar practiced more MVPA during school hours than during out-of-school hours, contradicting the research in pre-school [42] and older children [43]. One explanation for this could stem from the regional and cultural influences including climate. Due to the severe heat, it is problematic for children to walk to and from school. Additional initiatives are required, possibly from the ministry level, to encourage activities during breaks if PA levels are to be improved. There are several studies that feature practical applications that could be implemented at school to promote PA [44], although these strategies may need to be adapted for the climate and culture in Qatar.

Qatar has an opportunity due to the current staging of the FIFA World Cup to more effectively target school children in engaging in physical activities as there is suggestive evidence that hosting sports mega events (SMEs) creates considerable excitement that can be harnessed to design and implement targeted approaches to enhance PA in children. At a pragmatic level, the availability of multiple sports complexes recently built for the World Cup in multiple areas of this small nation should enhance the chances of positive results provided that the implementation is systematic and a result of a well thought out framework.

One of this study's limitations was that participants were recruited from only two schools, and although we collected data for a sufficient time, a larger cohort would produce more accurate insights. Although the initial excitement about taking part in the study was high, many students dropped out early, leaving us with a smaller than anticipated cohort. Some students' parents cited data privacy concerns as their reason for not taking part. Another limitation is that the participants knew they were being observed, and this may have induced an increase in PA; although from a study design perspective, we are not sure if we could have avoided this. In other words, the results may be overstated, but the underlying conclusion remains the same: Qatari adolescents are not meeting the PA recommendations.

The applicability and generalizability of the findings are limited due to the small sample size and narrow age range included in this study. Additional studies involving participants from more schools across the country (both private and public) are required to establish whether our findings can be generalized for all high school children PA in Qatar. Furthermore, with a larger dataset, we could apply AI and ML techniques to forecast, predict, and estimate effects on BMI, and develop models to allow for more personalized recommendations for each participant based on the time-series data.

5. Conclusions

High school children in two Qatari schools did not meet the MVPA or steps/day recommendations. Larger studies across this region are needed to determine whether this is a common trend. Gender differences were observed in PA levels and steps per day, in line with previous studies such as Diouf et al., who observed that boys spent more time in MVPA than girls, outlining that it could be related to the type and or intensity of activities practiced during their leisure-time [40]. Here, there was a pattern of more PA performance and steps during the week days as opposed to the weekend, but these values showed no robust evidence in favor of H1 or statistical significance when it comes to step count. However, the evidence is robust in favor of H1 (difference between weekend and weekday) due to a statistically significant difference for meeting the 60 min/day activity. Our study results highlight the need to design educational strategies and programs to improve PA levels in the Qatari high school population. Future work should target more schools in the region to establish whether our findings can be generalized for the Qatari population.

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Abbreviations

PA	Physical Activity
WCM-Q	Weill Cornell Medicine-Qatar
MVPA	Moderate-to-vigorous Physical Activity
MPA	Moderate Physical Activity
VPA	Vigorous (Very Active) Physical Activity
WD	Wearable Device
AI	Artificial Intelligence
SIHA	System for Integrated Health Analytics

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