

Artículo original. Could a gamified intermittent teaching unit in Physical Education enhance primary schoolchildren's regular physical activity? Vol. 11, n.º 2; p. 1-26. April 2025.

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Could a gamified intermittent teaching unit in Physical Education enhance primary schoolchildren's regular physical activity?

¿Podría una unidad didáctica intermitente gamificada en Educación Física mejorar la actividad física regular de los niños de Primaria?

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Ethical Committee for Human Studies at the University of Granada (code number: 956/CEIH/2019).

Abstract

The main aim of the present study was to analyze the effect of a gamified intermittent teaching unit using a combination of behavior modification strategies (i.e., activity wristbands, goal-setting, educational counseling, physical activity reminders, and physical activity diaries) in the Physical Education setting on primary schoolchildren's activity wristband-measured weekly steps. 121 primary schoolchildren (final sample = 103; 45.6% females; 9-12 years) from a public school performed a gamified intermittent teaching unit (first 15 minutes of each session, three times per week for five weeks). Several behavior modification strategies were combined during the intervention (i.e., activity wristbands, goal-setting, physical activity reminders, diary, and educational counseling) in order to promote participants' daily physical activity. Schoolchildren's daily steps were recorded at the baseline week and during the fifth intervention week by the Garmin Vivofit Jr 3 activity wristbands. The Multilevel Linear Model results showed that schoolchildren improved their weekly steps from the baseline week to the fifth week of the program ($p = 0.044$; $d = 0.19$). Also, schoolchildren improved the percentage of schoolchildren reaching, on average, 10,000 steps per day at week five compared with baseline week ($p = 0.035$; Cramer's $V = 0.477$). A gamified intermittent teaching unit using a combination of behavior modification strategies for increasing schoolchildren's active behavior seems effective for improving their weekly steps.

Keywords: primary education; behavior modification strategies; innovative program; gamification; steps.

Resumen

El objetivo principal del presente estudio fue analizar el efecto de una unidad didáctica intermitente gamificada que utiliza una combinación de estrategias de modificación de conducta (es decir, pulseras de actividad, establecimiento de objetivos, asesoramiento educativo, recordatorios de actividad física y diarios de actividad física) en el contexto de la Educación Física sobre los pasos semanales medidos con pulseras de actividad de niños de primaria. 121 niños de primaria (muestra final = 103; 45,6 mujeres; 9-12 años) de un colegio público realizaron una unidad didáctica intermitente gamificada (primeros 15 minutos de cada sesión, tres veces por semana durante cinco semanas). Varias estrategias de modificación de conducta fueron combinadas durante la intervención (es decir, pulseras de actividad, establecimiento de objetivos, recordatorios de actividad física, diario y asesoramiento educativo) con el fin de promover la actividad física diaria de los participantes. Los pasos diarios de los escolares se registraron en la semana basal y durante la quinta semana de intervención mediante las pulseras de actividad Garmin Vivofit Jr 3. Los resultados del Modelo Lineal Multinivel mostraron que los escolares mejoraron sus pasos semanales desde la semana basal hasta la quinta semana del programa ($p = 0,044$; $d = 0,19$). Además, los escolares mejoraron el porcentaje de escolares que alcanzaron, en promedio, 10.000 pasos por día en la semana cinco en comparación con la semana basal ($p = 0,035$; Cramer's $V = 0,477$). Una unidad

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didáctica intermitente gamificada que utiliza una combinación de estrategias de modificación de conducta para aumentar el comportamiento activo de los escolares parece eficaz para mejorar sus pasos semanales.

Palabras clave: educación primaria; estrategias de modificación de conducta; programa innovador; gamificación; pasos.

Introduction

The high prevalence of physical inactivity in schoolchildren worldwide is estimated to be around an 80% non-compliance to the World Health Organization's (WHO) physical activity (PA) recommendations (OECD/WHO, 2023). The amount of benefits provided by regular PA (i.e., physical, social and mental benefits, OECD/WHO, 2023) influences international organizations to focus their policies on this global problem (OECD/WHO, 2023). For instance, specifically in Educational Systems, the national standards of most countries' curriculums include the promotion of regular PA, and focus on the subject of Physical Education (PE) to address this issue (OECD/WHO, 2023). Moreover, the international WHO (2020) PA recommendations (at least 60 minutes of moderate-to-vigorous PA per day) have been recently translated to daily steps in order to facilitate the control of regular PA for PE teachers in their educational setting (around 10.000 steps per day along the week, Mayorga-Vega et al., 2021).

Some health-promotion programs centered in increasing regular PA have been applied successfully in the PE context (Casado-Robles et al., 2022a; Guijarro-Romero et al., 2023), but not without some particular difficulties associated to this complex setting. Some of the difficulties that these kinds of programs have to overcome are: the assessment of regular PA during schoolchildren's leisure time; the limited time allotted to PE programs due to the large amount of objectives and contents that have to be developed in the educational curriculum by PE teachers (Casado-Robles et al., 2019); the control of psychological mediators of PA practice (Guijarro-Romero et al., 2023); the schoolchildren's low motivation for practicing PA in their leisure time (Franco et al., 2020); or the scarce autonomy and procedural knowledge of schoolchildren in their leisure time to practice PA (Casado-Robles et al., 2022a).

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In this sense, Viciano and Mayorga-Vega (2016) proposed to redistribute the time of learning into new structures of the teaching unit in order to facilitate the treatment of this complex issue and to solve some of the above-mentioned problems (i.e. limited time allotted to PE programs, schoolchildren's low motivation, etc.). Among these new structures, there is the "intermittent" teaching unit (TU), whose structure consists of dividing the PE session into two (or more) parts, working particular objectives during some minutes of each session, for instance the first 15 minutes, for several sessions, leaving the second part of the session for a different curricular objective. This distributed practice for schoolchildren's learning lets PE teachers work more efficiently in different ways: 1) associating the first objective of the PE session with the second one (e.g., working sport learning in the second part of the session, but pointing out its role in increasing regular PA if they practice in their leisure time; or 2) practicing to achieve the objectives in a longer term, avoiding forgetfulness and promoting a better and more meaningful learning. Although some previous studies have applied this new distribution of time using the intermittent TU for developing and maintaining different health-related curricular objectives over the time, such as improving cardiorespiratory fitness (Guijarro-Romero et al., 2020), as far as we know, to date, they have not been delivered with the objective of promoting schoolchildren's objectively-measured regular PA.

Apart from the distribution of the learning time, other methodological characteristics of interventions in the PE setting are crucial to successfully achieve the goals set out in a PA-promotion program. Gamification is considered one of the most motivational methodologies that implicates schoolchildren in their own learning process, participating with enjoyment and involvement in a dynamic way such as a gamified story as a background (Arufe-Giráldez et al., 2022; Blázquez & Flores, 2022). This gamified dynamic entails particular game mechanics (i.e., rules, collaborative problem solving, immediate feedback, levels, or increasing challenges, etc.); some special components (i.e., characters, player control, points, badges, leaderboards, or rankings); and everything developed with social and collaborative interactions (Blázquez & Flores, 2022). Different previous gamified interventions have

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demonstrated their effects on various objectives related to health in the PE setting [e.g., Cenizo-Benjumea et al., (2022) for increasing physical fitness; Fernández-Río et al., (2020) for motor engagement and motivation; or Silva Piñeiro (2024) for the acquisition of healthy habits]. In general and as far as we know, the effectiveness of this methodology has been studied in different schoolchildren's ages (including three studies with primary schoolchildren) in the recent meta-analysis carried out by Mazeas et al. (2022).

Finally, aside from using technology resources in a positive way regarding the promotion of PA (instead of being misused, as commonly is the case), activity wristbands have demonstrated to be feasible and useful in the PE setting, and good help for PE teachers in order to evaluate and control PA parameters, such as daily steps in free-living conditions (Mayorga-Vega et al., 2023), as well as to motivate and help schoolchildren practice PA (Strath & Rowley, 2018). Moreover, the activity wristbands' steps score has shown to be a valid parameter for classifying schoolchildren as meeting or not meeting the PA recommendations as a dichotomous variable (Mayorga-Vega et al., 2021). In a recent meta-analysis by Casado-Robles et al. (2022b), a moderate effect for promoting PA practice in the PE setting was detected when using activity wristbands as the main strategy to change schoolchildren's active behavior. Effectiveness increases when combining activity wristbands with other behavior modification strategies such as gamified programs, goal-setting, educational counseling, PA reminders or PA diaries (Casado-Robles et al., 2022b). However, to the best of our knowledge, programs applying activity wristbands combined with other strategies for promoting regular practice of PA in primary schoolchildren in the PE context have still not been applied. Therefore, the main aim of this study was to analyze the effect of a gamified intermittent TU (GITU) using a combination of behavior modification strategies (i.e., activity wristbands, goal-setting, educational counseling, PA reminders, and PA diaries) in the PE context on primary schoolchildren's activity wristband-measured weekly steps.

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Method

Study design

The Declaration of Helsinki statements (64th WMA, Brazil, October 2013), and the approval of the protocol by the Ethical Committee for Human Studies at the University of Granada (code number: 956/CEIH/2019) have been followed and achieved in this research, respectively. Due to the nature of the present study, a non-blinded (for schoolchildren or teachers) quasi-experimental (longitudinal) single group repeated measures design was followed (Des Jarlais et al., 2004). The recruitment of participants was carried out in September 2022 and the intervention was done from October 2022 to December 2022.

Participants

One public school of Granada (Granada, Spain), chosen by convenience, was contacted through their principal and the PE teacher, and they were informed about main objective of the study, requesting their permission to carry it out in their schools. After the approvals was obtained, all 158 schoolchildren (44.3% females) from the fourth to sixth grades of Primary Education (i.e., 9–12 years old) were invited to participate in the present study. Verbal assent from schoolchildren and signed written informed consent of their legal guardians were collected after they were informed of the general characteristics of the study. All of the students belonged to middle-high socioeconomic level families.

The inclusion criteria were: 1) belonging to the fourth-to-sixth grade in the Primary Education stage; 2) the attendance of normal PE sessions; 3) being exempt of any health problem that would make them unable to engage in PA practice; 4) presenting both, the corresponding signed written consent by their legal guardians, and their own signed verbal assent. The exclusion criterion was not having daily steps recorded of both the baseline and fifth week, with at least five valid days per week.

Measures

Prior to carrying out the GITU, gender (males/females), age (in years), non-dominant hand (left/right), and previous and current activity wristband use information

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was self-reported by schoolchildren. All evaluations detailed bellow were performed by the same tester, instruments, and protocols.

Anthropometric data

International Standards for Anthropometric Assessment were followed to take the participants' anthropometric measures (Stewart et al., 2011). Afterwards, the body mass was divided by body height squared (kg/m^2) in order to calculate the body mass index. Body mass index cut-points to categorize participants as overweight/obese or non-overweight/obese (i.e., gender- and age-adjusted cut-point was the equivalent value of 25 kg/m^2 at the age of 18 years) were used (Cole et al., 2000).

Activity wristband measured weekly steps

Schoolchildren's weekly steps were objectively measured with the Garmin Vivofit Jr 3 (Garmin, Olathe, Kansas, USA) activity wristband, which was worn during the baseline (i.e., one week before the GITU) and fifth week of the GITU as measurements of the dependent variable. This activity wristband has shown excellent validity for assessing daily steps under unstructured free-living conditions specifically for schoolchildren (Mayorga-Vega et al., 2023). Activity wristbands were placed on participants' non-dominant hand wrist, close to, and above the wrist bone. Garmin Vivofit Jr 3 wristbands are small, light ($1.41 \times 1.41 \times 1.20 \text{ cm}$, 25 g), and have their own algorithmic formula based in tri-axial built-in accelerometers to estimate steps taken by the user. Regarding the data scoring and as previous studies have established (Lubans et al., 2015), registers with less than 1,000 steps or more than 30,000 per day were considered non-valid days, and they were omitted for the final data analyses in the present study. Moreover, having five valid days during the week was the criterion to allow calculating the participants' average steps in a particular week (Migueles et al., 2017). Finally, in order to classify schoolchildren reaching or not the 10,000-steps/day recommendations during a week (Mayorga-Vega et al., 2021), steps/day value were averaged.

Intervention

Before the GITU, several guidelines for delivering the sessions according to plan were designed by the researchers. During the application of the GITU, guidelines were

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provided to the PE teacher in a weekly meeting. Also, the main researcher supervised all the sessions of the GITU making sure the guidelines were considered.

Schoolchildren received a five-week (three sessions/week) GITU (Blázquez & Flores, 2022; Viciano & Mayorga-Vega, 2016). Particularly, the first 15 minutes of each session were considered for the specific work of PA promotion of the GITU. The second part of the sessions' time was applied to football and basketball sport learning. According to Casado-Robles et al. (2022b) several behavior modification strategies were combined during the GITU (i.e., activity wristbands specifically designed for children, goal-setting, PA reminders, PA diaries, and educational counseling). Particularly, the GITU was organized as follows: in the first week the complete GITU was presented (i.e., explanation of the general aim of the "Andaluzo's adventure", which was the starring character of the GITU that has the mission of completing a trip through the region of Andalusia allocated in the south of Spain; information about the characteristics of the activity wristband such as care, or proper use; the explanation of the use of some game components like the healthy passport, or the personal PA diary; and the formation of cooperative groups for accomplishing the mission with their representative avatars that were used as tokens on a game board that was the Andalusian map). From the first to the fifth week of the GITU the narrative of the gamified intervention was developed, which consists of overcoming the eight levels of the adventure. The character of Andaluzo was traveling inside the Andalusia region visiting all its eight provinces, and discovering traditional games to play within each of the provinces achieved. Moreover, from the second week forward, four challenges were established with a progressive minimum number of steps to accomplish, both individual (registered with a stamp in the schoolchildren's individual healthy passport) and in-group (averaging the steps of all participants of the group in a collaborative way during the week, and evolving with the avatar on the Andalusia board as the group achieves each of the challenges, which was posted on the classroom' wall). Particularly, and according to previous literature, the number of daily steps per the weeks two, three, four, and five were 9,000, 10,000, 11,000, and 12,000 steps/day, respectively, applying an adaptive steps goal-setting strategy (Mayorga-Vega et al., 2021). Typical games from each of the Andalusian provinces were deactivated when groups overcame each of the

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challenges (i.e., levels of the game), playing with those games during the rest of the PE class while at the same time promoting the local culture of the region commenting cultural and sports anecdotes of the provinces they belong to. In order to promote regular PA, schoolchildren wore the Garmin Vivofit Jr 3 activity wristband for children during the entire GITU (i.e., 24h during the five weeks). Displays of activity wristbands informed participants in real time of their steps performed day by day, which was used as the main strategy in the GITU to engage them in increasing their PA, following the progressive step goals of the week (Casado-Robles et al., 2022b). According to Casado-Robles et al. (2022b), educational counseling was also applied together with the activity wristbands, and the use of a gamified sessions with an adaptive step goal-setting during the intermittent TU. This educational counseling included PA recommendations, analysis of benefits of regular PA, different intensities of PA to perform in order to achieve the recommended daily PA (PA pyramid), feedback to participants about their achievement or not of their number of steps they were supposed to perform, PA practice proposals for school recess and the schoolchildren's leisure time, the use of sensitizing videos and news about PA practice to raise awareness of the PA practice, and the proposal of ten health mandates. In regard to the feedback about the steps performed by schoolchildren, positive reinforcements were delivered to participants who accomplished the weekly challenges both individually and in-group, and they provided at the same time activities they performed to the rest of their mates in the classroom as examples of good practices. On the contrary, those participants that did not overcome the daily challenges were asked to analyze barriers found for practicing PA during their leisure time, proposing alternatives using the immediate environment in order to improve their achievements. Finally, the end of the GITU included a festive and social atmosphere where achievements were analyzed, diplomas for participation were awarded, and the most active participants were also awarded according to the best step data, encouraging them to continue with the same number of daily steps autonomously in the future (i.e., 12,000 steps/day).

Statistical analysis

Descriptive statistics (means and standard deviations, adjusted means and standard errors or percentages) were computed for general characteristics of the

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participants and dependent variables. Furthermore, statistical test assumptions were checked by common procedures (e.g., histograms and Q-Q plots for normality) and met.

Next, the effect of the GITU on schoolchildren's weekly steps (i.e., continuous variable) was examined. All the participants were included in the statistical analyses regardless of adherence to the protocol (i.e., intention-to-treat approach). However, since the implementation of the missing data requires strong assumptions that are hard to justify, "complete case" analyses including only those whose outcomes were known were used (i.e., $n = 103$) (Campbell et al., 2012). Because the unit of intervention was the class, the Multilevel Linear Model (MLM) with participants nested within classes and measures nested within participants was performed (i.e., one-way nested ANCOVA). Gender and body mass index were used as the covariables from all the potential confounding variables explored (i.e., gender, age, body mass, body height, body mass index, previous activity wristband use, current activity wristband use, attendance rate, and wave). The maximum likelihood estimation method was used. Moreover, the exact McNemar's test was used in order to examine the effect of the GITU on the percentage of schoolchildren doing at least an average of 10,000 steps per day across the week. Effect sizes were estimated using the Cohen's d (continuous variables) and Cramer's V (categorical variables) for the pairwise comparisons. Finally, although an intention-to-treat approach was followed in the present study, as sensitivity analyses, all the above-mentioned analyses were also carried out with a per-protocol approach (i.e., including the participants, taking into consideration their adherence to the protocol, that is, ≥ 13 sessions -85%-). All statistical analyses were performed using the SPSS version 25.0 for Windows (IBM® SPSS® Statistics, Chicago, IL, USA). The statistical significance level was set at $p < 0.05$.

Results

Final sample and general characteristics

From the total of 158 schoolchildren (88 males and 70 females; 52 fourth graders, 56 fifth graders, and 50 sixth graders) who were invited to participate in the present study, an initial sample of 121 schoolchildren (64 males and 57 females; 46 fourth graders, 29 fifth graders, and 46 sixth graders) agreed and met the inclusion

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criteria. Since 18 schoolchildren (8 males and 10 females; 9 fourth graders, 5 fifth graders, and 4 sixth graders) met the exclusion criterion, the final sample consisted of 103 participants (56 males and 47 females; 37 fourth graders, 24 fifth graders, and 42 sixth graders i.e., non-compliance rate of 14.9%), who were included, having steps data of the baseline week and the fifth week with at least five valid days (i.e., 85.1%, average number of days per week = 6.8; total number of valid data = 1,407 days; mean = 101 per day, minimum = 96, maximum = 103). Table 1 shows the general characteristics of the included participants.

Table n.º 1. *General characteristics of the participants*

	Initial sample (N = 121)	Final sample (N = 103)
Age (years) ^a	9.9 (0.9)	10.0 (0.9)
Grade (4 th /5 th /6 th) ^b	38.0/24.0/38.0	35.9/23.3/40.8
Gender (females/males) ^b	47.1/52.9	45.6/54.4
Body mass (kg) ^a	38.6 (10.2)	38.7 (9.8)
Body height (cm) ^a	143.6 (9.2)	144.0 (8.7)
Body mass index (kg/m ²) ^a	18.5 (3.3)	18.4 (3.3)
Overweight/obesity (no/yes) ^b	69.2/30.8	70.9/21.1
Activity wristband previous use (no/yes) ^b	34.7/65.3	34.0/66.0
Activity wristband current use (no/yes) ^b	67.8/32.2	65.0/35.0
Weekly steps (steps/day) ^{a,c}	11,294.8 (2753.7)	11,357.0 (2744.4)
Meeting ≥ 10,000 steps/day (no/yes) ^{b,c}	34.5/65.5	34.0/66.0
Teaching unit attendance rate (%) ^a	93.2 (9.5)	93.5 (9.2)
Teaching unit attendance (sessions) ^a	14.0 (1.4)	14.0 (1.4)
Teaching unit attendance ≥ 13 sessions (no/yes) ^b	13.3/86.7	11.7/88.3

Note. ^a Data are reported as mean (standard deviation) for continuous variables and ^b percentage for categorical variables; ^c Steps data for baseline.

Effect of the gamified intermittent teaching unit on schoolchildren's activity wristband-measured weekly steps

The MLM results showed that the participants registered a statistically significant increase in weekly steps from the baseline week (M = 11,357.0; SE = 242.9) to week five (M = 11,824.9; SE = 242.9) (-2LL = 3,764.852; $F = 4.147$; $p = 0.044$; $d = 0.19$). The sensitivity analysis (i.e., per-protocol approach) found the same outcomes as the main analysis with the intention-to-treat approach ($n = 91$, week 0, M = 11,407.3, SE = 257.3; week 5, M = 11,868.7, SE = 257.3; MLM, -2LL = 3,315.2; $F = 4.133$; $p = 0.045$; $d = 0.19$) (Figure 1).

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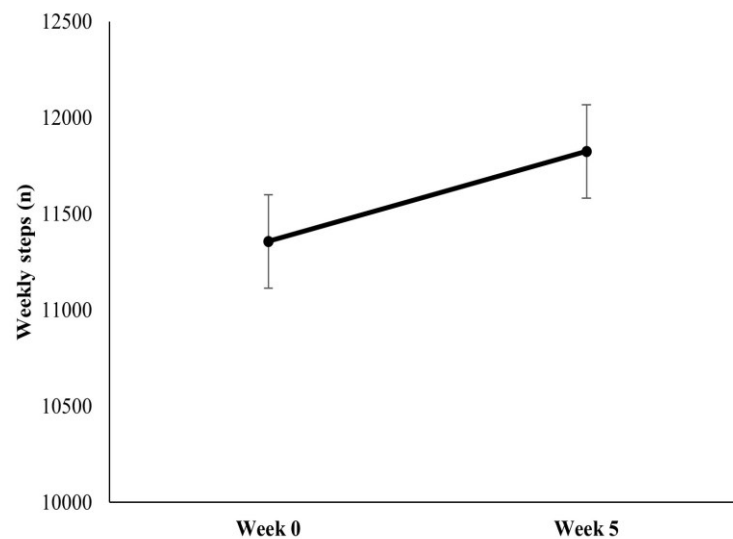


Figure nº. 1. Effect of the gamified intermittent teaching unit on schoolchildren's weekly steps ($n = 103$). Values are reported as adjusted means (by the covariable gender and body mass index) and error bars as standard error (SE).

The results of the McNemar's test showed that there was a statistically significantly higher percentage of schoolchildren that did at least an average of 10,000 steps per day at week five ($n = 79$; 76.7%) compared with the baseline week ($n = 68$; 66.0%) ($p = 0.035$; Cramer's $V = 0.477$) (Figure 2). The sensitivity analysis (i.e., per-protocol approach) found the same outcomes as the main analysis with the intention-to-treat approach ($n = 91$, week 0, $n = 60$, 65.9%; week 5, $n = 71$, % = 78.0%; McNemar's test, $p = 0.019$; Cramer's $V = 0.514$).

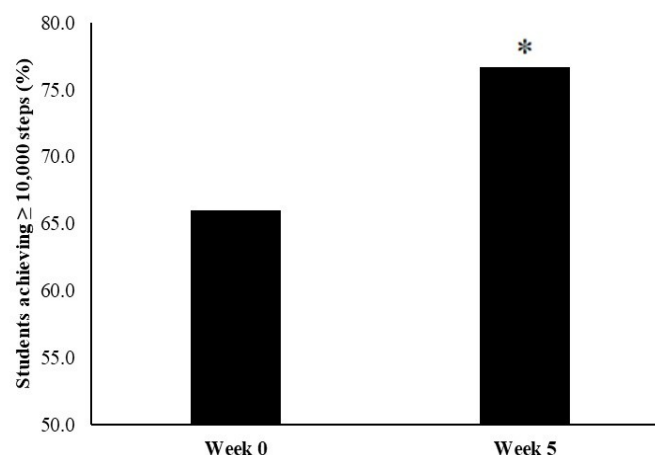


Figure nº. 2. Effect of the gamified intermittent teaching unit on the percentage of schoolchildren achieving, on average, at least 10,000 daily steps across the week ($n = 103$). Values are reported as percentage. * = $p < 0.05$.

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Discussion

The objective of the present study was to analyze the effect of a GITU using a combination of behavior modification strategies (e.g., activity wristbands, goal-setting, educational counseling, PA reminders, and diary) in the PE context on primary schoolchildren's activity wristband-measured weekly steps. Results have shown that the schoolchildren who performed the GITU using activity wristbands enhanced the activity wristbands-measured weekly steps regarding their baseline level, and also improved the percentage of participants achieving the 10,000-step-per-day recommendation, suggesting that the objective of the study was successfully achieved. These findings reinforce the viability of gamified interventions in the PE context to improve active behavior in schoolchildren (Mazeas et al., 2022; Silva Piñeiro, 2024). Unfortunately, to the best of our knowledge, no previous studies have been found that examine the effect of a GITU (Vicianá & Mayorga-Vega, 2016) combining gamification, activity wristbands, goal-setting, educational counseling, PA reminders, and PA diaries on schoolchildren's PA promotion in the PE context. Nevertheless, there is some previous research to compare results of the present study with, but there are also some clarifications to be made. Increasing daily PA in schoolchildren is a complex problem that depends on many factors of different nature [e.g., biological (Hu et al., 2021); psychological (Guijarro-Romero et al., 2023); circumstantial factors such as security while practicing PA, temperature (climate), or rain (weather) (Zheng et al., 2021); or type of intervention program applied (Casado-Robles et al., 2022b); etc.]. To date, although similar previous studies carried out with schoolchildren in the PE setting have been developed using activity wristbands, some other differences have appeared according to each of the study research designs (characteristics of the sample, number and type of behavior modification strategies applied to participants, or influential variables, among others). These studies' characteristics have caused inconsistent and limited antecedents of the present results.

On one hand, some previous studies have had positive results on regular PA using activity wristbands. Specifically with schoolchildren, Eyre et al. (2016) managed to increase daily steps significantly after a six-week program, but with a special sample

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of South Asian Children from a low-income area, which probably saw an influence on results due to their low level of daily steps at the beginning of the program, and the season could also be an influence, as the program was performed in a time of good weather, as the authors recognized in their report. Garde et al (2015) detected that schoolchildren (8-13 years old) increased their PA after a 14-day (two-week) program, independently if they were in the gamification group (using a game app for iPhones and competing between them; $d = 0.14$) or in the feedback group (where the participants were informed of steps and active minutes performed day by day; $d = 0.12$). These same authors obtained similar results increasing 46 minutes and 2934 steps/day using a new gamified intervention with schoolchildren (Garde et al., 2016). In a third study, these same authors studied in a two-week intervention program the effect of gamification and socioeconomic levels of different groups on the increment of PA (Garde et al., 2018). These authors also detected an increment of PA in all groups, but greater in the group of lower socioeconomic level and lower levels of PA at the baseline measurement, which is in line with results obtained by Eyre et al (2016).

Similar to the present study, other studies carried out with adolescents have obtained positive results: 1) Guijarro-Romero et al. (2023) with an eight-week intermittent TU combining progressive goal-setting, educational counseling, activity wristbands, and focusing on psychological mediators (i.e., motivation, intention to be active, and basic psychological needs) increased the adolescents' self-reported perception of daily PA ($d = 0.10$); 2) Remmert et al. (2019) studied a low-level PA baseline group of adolescents, applying a 10-session PE-based program combined with counseling after PE classes. These authors obtained an important increase of 1,200 steps/day after the post-intervention evaluation ($d = 0.41$); and 3) Gaudet et al. (2017) using activity wristbands and a goal-setting strategy found an increase of moderate-to-vigorous PA (15 minutes more a day) with a seven-week intervention program ($d = 0.38$), but this increment was only experienced by a specific subgroup (i.e., those participants who were in an adoption stage to change their behavior, which is a higher disposition to change their behavior to a more active one, Hagler et al., 2006).

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All of these increments of PA experienced in the above-commented studies (Eyre, et al., 2016; Garde et al., 2018; Garde et al., 2016; Garde et al., 2015; Gaudet et al, 2017; Guijarro-Romero et al., 2023; Remmert et al., 2019) are in line with the present study. However, results were slightly different due to some circumstantial differences. Beside the differences of age in the present sample with those studied in Guijarro-Romero et al. (2023), Remmert et al. (2019), and Gaudet et al. (2017), the schoolchildren's socioeconomic level of the present sample was medium-high and, on average, their initial level of PA during the baseline was moderately high [even most of the schoolchildren (66%) exceeding the recommended daily levels of steps], unlike the studies of Eyre et al. (2016) and Remmert et al. (2019). Secondly, the effects of weather (i.e., rain and temperature) of Granada (Spain) could also have an influence on the final PA level reached. As Eyre et al. (2016) recognized in their study, the present research started with higher temperatures and better weather conditions than at the final week of intervention, which coincide with the main results of the systematic revision of this topic made by Zheng et al. (2021). The structure of the scholar year in Spain, that starts in September (at the end of summertime), could have influenced the overall results of this study. The duration of the GITU implementation and the different evaluations (baseline and post-intervention) caused weather differences between the first measurement (i.e., baseline, in September) and the final one (post-intervention measurement, which was made in autumn close to wintertime, at the beginning of December). The above-commented arguments (i.e., socioeconomic level of the sample and the high level of PA at the baseline, and the differences in weather conditions experienced between pre- and post-intervention measurements) could influence on the scarce increment of PA, although significant, obtained after the intermittent TU. Consequently, and regarding the magnitude of the effects of the intervention, most of these previous studies that have applied gamification programs found higher effects on schoolchildren's daily steps ($d = 1.17$, 95% confidence interval 0.58-1.76) (Eyre et al., 2016; Garde et al., 2018, Garde et al., 2016) than in the present study ($d = 0.19$).

In regard to the number of participants reaching the international PA recommendations (WHO, 2020), to date, only Galy et al. (2019) coincided with the

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present study by obtaining an objectively-measured increment of schoolchildren's number of days per week fulfilling the PA recommendations (from 2.5 to 3.5 days/week) using a gamified and technology-based educational program with PA trackers, but with adolescents. In the present study, despite a high percentage of participants that were achieving the worldwide recommendations at the beginning of the GITU, a significant increase of that percentage was registered (i.e., from 65.9% in the baseline to 78.0% in the fifth week). This is an important achievement of this study, mainly due to the high prevalence of inactivity registered worldwide by literature, both in schoolchildren and adolescents (Aubert et al., 2021) and the above-mentioned high percentage of schoolchildren accomplishing the daily steps recommendations at the baseline measurement.

However, on the other hand, there are studies that have had no effects on PA. Specifically with schoolchildren, the study of Evans et al. (2017) applied activity wristbands and goal-setting strategies in a four-week intervention program without any increase in moderate-to-vigorous PA or daily steps. Possibly their main difference with the present study was that these authors explained that children may not have the requisite level of executive functioning needed in order to identify conducts to increase their PA independently, apart from those developed in PE classes or structured sports practice (Anderson, 2001; Evans et al., 2017). This is an interesting point that should be studied in depth, nevertheless, it is not very clear in their study which factors are involved in how schoolchildren of different ages are able to identify good practices toward increasing regular PA and if they are able to apply them to their lives. With adolescents, three studies have been found with activity wristbands and without any effect on regular PA: 1) only using activity wristbands and some orientations toward how to use them, Kerner et al. (2019) did not find any increase in daily PA after a five-week intervention program. The main difference with the present study that could explain disparities on overall results with Kerner et al. (2019) was that they did not use PE classes as a part of the intervention nor any strategy other than leaving adolescents more autonomously using activity wristbands; 2) Bronikowski et al. (2016) did not find either effect in moderate-to-vigorous PA or daily steps performed by adolescents after

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an eight-week program combining activity wristbands and goal-setting strategy. Unlike the present study, Bronikowski et al. (2016) did not use educational counseling combined with activity wristbands, moreover, the teachers' intervention regarding the autonomy support was not homogeneous for all participants, as they recognized throughout the registered qualitative data, which could influence overall results; and 3) Corepal et al. (2019) did not obtain any increase on moderate-to-vigorous PA/day or steps/day after a 22-week program. In this case, unlike the present study, summertime was also included in the program, with all the limitations that it supposes regarding PE teachers support, with the consequent decrease of effectiveness of this strategy. Moreover, although they applied other strategies such as competitions during their program, foreseen rewards were not enough to provide positive feedback to all participants, as registered by the data reported by the qualitative instruments.

Therefore, to address the complexity of the problem of increasing regular PA, many factors must to be taken into account. It seems that age of participants (Hu et al., 2021), their intention to be active and the stage of implementation of this active behavior (Guijarro-Romero et al., 2023; Hagler et al., 2006), their initial level of PA (Eyre et al., 2016), the characteristics of the implemented program (i.e., number and the type of modification strategies, duration, etc.; see all above-mentioned studies), and the perceived teacher support (Corepal et al., 2019), influence on the effects obtained after the program has been implemented.

Due to its complexity, it is impossible to leave as complete the following conclusions regarding regular PA, but it is important to recommend programs for primary schoolchildren (aged between 9-12 years old) that include (Casado-Robles et al., 2022b): 1) the use of activity wristbands (instead of hip monitors) to provide feedback of the PA performed by the schoolchildren; 2) gamification characteristics, which provide motivation and active participation of schoolchildren (Arufe-Giráldez et al., 2022; Garde et al., 2018; Garde et al., 2016; Garde et al., 2015); 3) preferably the use of a combination of behavior modification strategies together with activity wristbands, in order to inform and motivate schoolchildren. These other behavior modification strategies to be applied would be goal-setting (Gaudet et al., 2017), to

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establish progressive goals to the desirable steps per day (10,000-12,000, Mayorga-Vega et al, 2021; WHO, 2020); and educational counseling to inform and raise awareness in participants of the importance of PA benefits, or encouraging them to perform PA with family and friends, among other information and recommendations (Casado-Robles et al., 2022b; Remmert, et al., 2019). Additionally to Casado-Robles et al. (2022b), other studies have found complementary information to add to the previous arguments, which are: 4) paying special attention to psychological mediators of PA in order to influence positively on the PA performed (i.e., motivation, basic psychological needs, intention to be active, among others, Guijarro-Romero et al., 2023; Hagler et al., 2006); and 5) using an intermittent TU in order to improve the management of the learning time in PE classes during the intervention (i.e., to interrelate the knowledge for practicing PA with how to use the immediate environment to practice it, and to avoid reducing motor engagement time when contents of the program are mainly theoretical such as the use of activity wristbands, PA benefits, PA barriers analysis, etc., Vicianá & Mayorga-Vega, 2016; Casado-Robles et al., 2022a; Guijarro-Romero et al., 2023). Nevertheless, it is necessary to confirm the effectiveness of these kinds of programs with new studies and approaches in the future in order to help grasp the manner in which PA behavior can be influenced and increased for schoolchildren in a more consistent way.

Strengths of this research are: 1) that to date and to our knowledge, this is the first study that analyzes the effect of a GITU using a combination of behavior modification strategies on objectively-measured weekly steps of schoolchildren [e.g., steps measured with activity wristbands, which have demonstrated to have an excellent validity for assessing schoolchildren's daily steps (Mayorga-Vega et al., 2023)]; and 2) the innovative distribution of the learning time of the GITU (i.e., only the first 15 minutes of all PE lessons of the program) instead of using the entire lessons in a concentrated way, as normal/traditional teaching units usually do. Consequently, PE teachers were allowed to: a) increment the motor engagement time of the PE lessons of the program despite developing theoretical contents during the transmission of PA information belonging to the educational counseling strategy; and b) interrelate the

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knowledge for practicing PA with how to use the immediate environment during the second part of the lessons. Furthermore, it has supposed an important novelty not implemented up to this point in regular PA promotion programs (Casado-Robles et al., 2022b; Viciano & Mayorga-Vega, 2016).

However, the present study has to recognize some limitations. First, the relatively small and non-probabilistic sample size causes a low generalization power (i.e., limited generalizability of obtained results to the specific context and sample). However, due to educational context, human, time, and material resource restrictions, a probabilistic and larger sample has been impossible to examine. Moreover, a control group could not be included and it supposes a higher risk of bias of the obtained results. The risk of bias refers to the possibility that the design of a study introduces systematic errors, potentially leading to incorrect conclusions. However, due to the viability and difficulties of these kinds of studies carried out in the educational setting (the rejection of closed educational centers to the experimental one in order to participate as a control one, the quantity of schoolchildren interested in participating, the impossibility of obtaining enough signed consents of parents and guardians, and the schedule organization of the year together with the number of necessary waves for collecting data due to the number of available activity wristbands) this group could not be included. Nevertheless, this is a common situation shared by 44.94% of activity wristband-based studies performed in the educational context analyzed by Casado-Robles et al. (2022b). Another limitation could come from the decline in compliance in wearing the activity wristbands, as schoolchildren who did not wear them might have been less active or less motivated to engage in PA. This could have led to an overestimation of the outcomes, depending on the extent to which non-adherence has affected the representativeness of the sample. However, the non-compliance rate has been recognized as one of the most important methodological limitations with objective PA measurement in schoolchildren under free-living conditions (Howie & Straker, 2016). In this sense, values registered in the present study (around 15%) are lower than those reported in previous studies that objectively measured weekly PA among schoolchildren, where noncompliance rates reached up to 75.4%, with a mean noncompliance rate of 37.4% (Howie & Straker,

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2016; St Fleur et al., 2021). Finally, as commented before during the discussion section, weather conditions could influence the quantity of PA performed by participants. For example, if the post-measurement had been performed under different weather conditions, such as spring, the scarce PA increment achieved after the intervention might have been greater. Nevertheless, if there was any influence it must have been negative on the PA levels registered at the post-measurement evaluation regarding the baseline. So even if there was an influence, the results of the GITU were still positive. Future research studies should include PA promotion programs with all characteristics described in this paper in relation with the combination of behavioral change strategies, larger samples, different ages, and controlling and enhancing positive psychological mediators in order to consolidate the knowledge around the complex problem of increasing regular PA in scholar ages.

Conclusion

In relation to the objective of the present study, a GITU that used a combination of behavior modification strategies improved daily steps of schoolchildren in the PE setting. The implemented GITU also improved the percentage of schoolchildren considered as “active”, achieving the recommended PA steps recommendations. This could help to achieve one of the most worrying National Standards present in the contemporary legislation in most countries all over the world (i.e., to eradicate the prevalence of inactivity and to improve PA in the leisure time of schoolchildren).

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