

Research Article

The Use of Physical Activity Mobile Apps Improves the Psychological State of Adolescents: A Randomized Controlled Trial

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Mobile applications positively influence the practice of physical activity in adolescents, but the effect of this improvement on the psychological state and the addictive use of technologies in this population is unknown. For this reason, the aims of the present investigation were to establish the differences in psychological variables and problematic mobile phone use by adolescents after a 10-week intervention with mobile apps, according to gender and the different mobile applications used. A randomized controlled trial was conducted in Spain with 400 adolescents aged 12–16 years (mean age: 13.96 ± 1.21 years old) whose physical activity level, satisfaction of competence, autonomy, and relatedness, life satisfaction, and addictive use of the mobile phone were measured. Two measurements were taken, with a 10-week intervention period in between. During the intervention, adolescents in the experimental group (EG) must use one of the selected mobile applications (Strava, Pacer, MapMyWalk, or Pokémon-Go) a minimum of 3 times per week, covering the distance indicated for each week. The use of the mobile applications was randomized for each class group, and an explanation was given to the adolescents prior to the start of the intervention. The results showed that EG showed a significant improvement in the psychological variables ($p = 0.003 - 0.036$) compared to the control group and also a decreased problematic mobile phone use ($p = 0.004$). Specifically, females in the EG increased autonomy ($p = 0.010$), relatedness ($p = 0.019$), and life satisfaction ($p = 0.020$), while males improved relatedness ($p = 0.021$) and competence ($p = 0.018$). In addition, the different applications used could influence autonomy, relatedness, and problematic mobile phone use. To conclude, the use of mobile step trackers could be useful to maintain an adequate psychological state of the adolescent population without increasing the addictive or problematic use of these technologies.

Trial Registration: ClinicalTrials.gov identifier: NCT04860128.

1. Introduction

1.1. Basic Psychological Needs (BPNSs) During Adolescence: Importance and Influencing Factors. Self-determination theory (SDT) enables the study of human motivation. More specifically, SDT defines intrinsic and extrinsic sources of motivation, as well as their importance in cognitive and social development and individual differences. This theory states that covering the needs for competence, autonomy,

and relatedness (BPNS) is fundamental to facilitate an adequate process of growth and integration, as well as constructive social development and personal well-being [1]. Autonomy has been defined as the desire to feel that one is the originator and regulator of one's own behavior [2]. Competence is the perception that individuals have of being able to show effectiveness within a particular context [3]. And relatedness refers to one's feeling of belonging to a particular social environment [4].

During adolescence, BPNS satisfaction becomes more relevant because this stage is characterized by physical, hormonal, and psychological changes [5, 6], which can affect the state of well-being of this population, as well as changes in the immediate social environment that lead to a change in the order of importance, with peers becoming more important than parents and siblings [7]. This fact is determinant for the integral development of this population, since adolescents who show peer attachment and school connectedness present prosocial behaviors [8], facilitating an adequate psychological development [9].

In addition to peer attachment and school connectedness, the practice of physical activity also has beneficial effects on the mental health of adolescents [10, 11]. Thus, adolescents who practice any type of physical activity on a regular basis show a greater satisfaction with the BPNS [12], as well as a greater satisfaction with life [13]. This is because during the practice of physical activity, responsibility, commitment, and interaction with other people are acquired, which favor the achievement of an optimal psychological state [14]. However, adolescents' physical activity has declined considerably in recent decades [15, 16]. This is because adolescents spend a lot of time on homework and after-school academic activities, which reduces the time available for after-school sports activities [17, 18]. In addition, it should not be forgotten that the mobility of this population is increasingly passive, as they increasingly rely on passive means of transport (e.g., car and bus) for their daily commute, as well as to go to school or to sports activities [19, 20]. This is coupled with the fact that there has been a change in the leisure activities of young people, who are increasingly using electronic devices instead of practicing sports activities [21, 22]. In addition, one of the main reasons why adolescents do not practice is because they have no one to do it with [23], neither friends nor parents do sports together with them. A possible explanation for this is that parents spend a high number of hours at work, which makes it impossible for them to practice sports [24], and previous research has shown a positive correlation between the physical activity of parents and that of children/adolescents [25]. Furthermore, these changes in the leisure time of the population were compounded by the COVID-19 pandemic [26]. One of the main consequences of the pandemic was the inability to engage in physical activity outdoors during the lockdown period [27], and although some types of physical activity could be performed indoors [28], it reduced opportunities for practice and resulted in restricted mobility for a period of 2 years, which negatively affected the physical activity level of adolescents [29], as well as the increased use of digital technologies, mainly the Internet and mobile phones, according to data collected in some European countries such as Sweden, Italy, or Spain [30–32].

1.2. Increased Use of Technology and Its Impact on the BPNSs of Adolescents. The excessive use of technologies during the pandemic was initially perceived as negative, as it increased the sedentary time of adolescents [33], and was associated with less practice of physical activity [34], affecting their ability to satisfy BPNS and their well-being [35, 36]. How-

ever, the increased use of technologies had a beneficial effect during the lockdown, as it allowed adolescents to maintain contact with their family and peers [37]; attend online classes at the education centers, taught by teachers [38]; to play video games or spend their time in different recreational activities, mitigating feelings of loneliness and stress [37]; and to increase the moderate to vigorous-intensity physical activity and perform muscle-strengthening exercises using mobile applications [39]. However, the use of digital technologies has remained excessively high postpandemic [40, 41], and the level of physical activity has not returned to pre-pandemic levels and, worse, has declined [42].

Among the most widely used digital technologies, smartphones are particularly relevant, as it has greatly increased after the COVID-19 pandemic in the adolescent population. In fact, adolescents have increased their postpandemic use of smartphones by more than 50% as compared to the prepandemic period [43]. This has had a negative impact on this population, negatively affecting healthy lifestyle habits such as the level of physical activity or their psychological state [44]. With regard to physical activity, previous research has shown that adolescents with higher levels of problematic mobile phone use have lower levels of physical activity compared to adolescents with nonproblematic and nonexcessive mobile phone use [45]; while in the psychological domain, adolescents with problematic mobile phone use showed higher mood disturbance (with significant reductions in vigor) and symptoms of depression compared to those without problematic mobile phone use [44].

1.3. Benefits of a Healthy Use of Digital Technologies for Adolescents. In light of the detrimental effects caused by the increased use of mobile phones, an attempt was made to reverse the situation, taking advantage of the growing and continuous use of mobile phones to improve the health of the adolescent population [46, 47]. For this reason, different interventions have been carried out with mobile applications, which have tried to improve nutritious food intake [48], weight control [49], or the level of physical activity [50] of adolescents. The latter is one of the most relevant and studied in previous research, with apps being useful to increase the level of physical activity in this population [51–53].

However, little is known about the benefits or harm of interventions using mobile applications to increase physical activity on the mental health of adolescents. This is because it is hypothesized that increasing physical activity using these tools will have beneficial effects on mental health, as is the case with traditional physical activity programs [54], although the abusive use of the mobile phone could have the opposite effect to that expected. Despite the interest in this topic, only one previous research study has analyzed the effect of interventions with mobile physical activity apps on the psychological state of the adolescent population [55]. This research study showed no significant effects on the satisfaction of BPNSs [55] and did not analyze whether the increased use of mobile applications could also increase the problematic mobile use in the adolescent population. In addition to all this, previous research using different physical activity mobile applications has shown different benefits

depending on the app used in physical activity and physical condition [56], which could also be a differential factor in the psychological domain, but this is an unknown factor so far.

1.4. Gender Differences in Physical Activity, Mental Health, and Technology Use During Adolescence. Furthermore, it should be noted that the practice of physical activity, mental health, and the use of digital technologies by male and female adolescents are considerably different, but none of the previous studies that investigated the effects of physical activity promotion via mobile apps on mental health considered the differences based on adolescent gender. Thus, males have a higher level of physical activity as compared to females [57]. Regarding mental health, considerable differences have been found depending on the variable studied, as males tend to present more externalizing problems, that are problematic for others such as antisocial personality or substance abuse or dependence, while females present more internalizing problems, such as depression or anxiety [58, 59]. This is why no gender differences in life satisfaction have been found [60], although in the case of BPNS, frustration seems to be more common among females [61]. Lastly, regarding the use of digital technologies, it seems that females are more prone and present more risk factors for mobile phone addiction [62]. This is because the time spent on mobile phones by females is longer than that of males [63], with a daily average of 166.78 min compared to 154.26 min [64]. In addition, females are more active users of communication and social networking applications, as well as entertainment applications and security functions, which has been linked in previous research to a higher risk of addiction [63]. In view of the above, gender could be a factor to consider when analyzing the effects of promoting physical activity through mobile applications, on the psychological state of this population.

1.5. Aims and Hypotheses. For this reason, the aims of the present study were (a) to establish the differences in psychological variables and problematic mobile phone use by adolescents after an intervention with mobile applications; (b) to analyze the differences in the study variables after an intervention with mobile applications according to the gender of the adolescents; and (c) to determine whether the different mobile applications used had an effect on the differences found in the study variables.

Based on previous research and the aims of the present study, the research hypotheses are as follows: (H1) The experimental group (EG) with mobile applications will show a slight but significant improvement in psychological variables, but also an increase in the addiction to mobile phones; (H2) differences will be found in the effects of the intervention based on the promotion of physical activity through the use of mobile applications, on psychological state and addiction to mobile phones according to gender; and (H3) there will be differences in the changes in the psychological state and addiction to mobile phones depending on the mobile applications used.

2. Materials and Methods

2.1. Design. This randomized controlled trial of a 10-week intervention was conducted in secondary schools and used mobile physical activity applications. Measurements were taken before and after the intervention for both pre and post-tests. The trial design was registered and followed the Consolidated Standards of Reporting Trials guidelines [65]. Ethical approval for the study was obtained from the Catholic University of Murcia (CE022102) and was implemented according to the guidelines of the Helsinki Declaration.

2.2. Participants. Two schools were selected for the intervention. To obtain a representative sample, the school with the highest number of students enrolled was selected. If this school declined participation, the next largest school was selected, with this process continuing until the two schools with the largest willing student samples were selected. Once the schools had been chosen, the classes that participated in the research were randomly selected. The management teams of the schools were contacted, and once their approval to carry out the research was obtained, the physical education teachers were contacted, and the procedure, the aims, and the role they were to play during the research study were explained to them. Subsequently, a face-to-face meeting was held with the adolescents interested in participating, as well as their parents, to explain the aims and the way in which the measurements would be carried out. The adolescents who were interested in participating provided an informed consent form signed by them and their parents in which they gave their approval to participate in the measurements and to use the mobile applications.

The sample size and power calculations were performed using Rstudio 3.15.0 software. Standard deviation was used according to standard deviation for physical activity interventions to improve the psychological state of the adolescent (autonomy SD = 3.50; competence SD = 2.40; relatedness SD = 2.12) [12]. This methodology for sample size calculation has been used in previous research [66]. The significance level was set at $\alpha = 0.05$ and a power of 95% ($1 - \beta = 0.95$). The minimum sample size required for the study was 357 adolescents. The sample size for each EG was determined based on previous research involving mobile apps in this population to improve life satisfaction (SD = 0.2) [67]. The minimum sample in each group was 40 adolescents.

Figure 1 shows the sample selection flowchart. A total of 400 adolescents finally participated in the study, 160 in the control group (CG) (105 males and 55 females) and 240 in the EG (105 males and 135 females), aged between 12 and 16 years old (mean age: 13.96 ± 1.21 years old). The participants were assigned to the groups with a cluster randomized design [68], with adolescents belonging to the same class using the same application, which explains the initial differences in n . Regarding the different gender profile between the CG and the EG, this is due to the fact that depending on the school, the number of males and females enrolled in compulsory secondary education is different [69], being also different in each particular class group, so that when

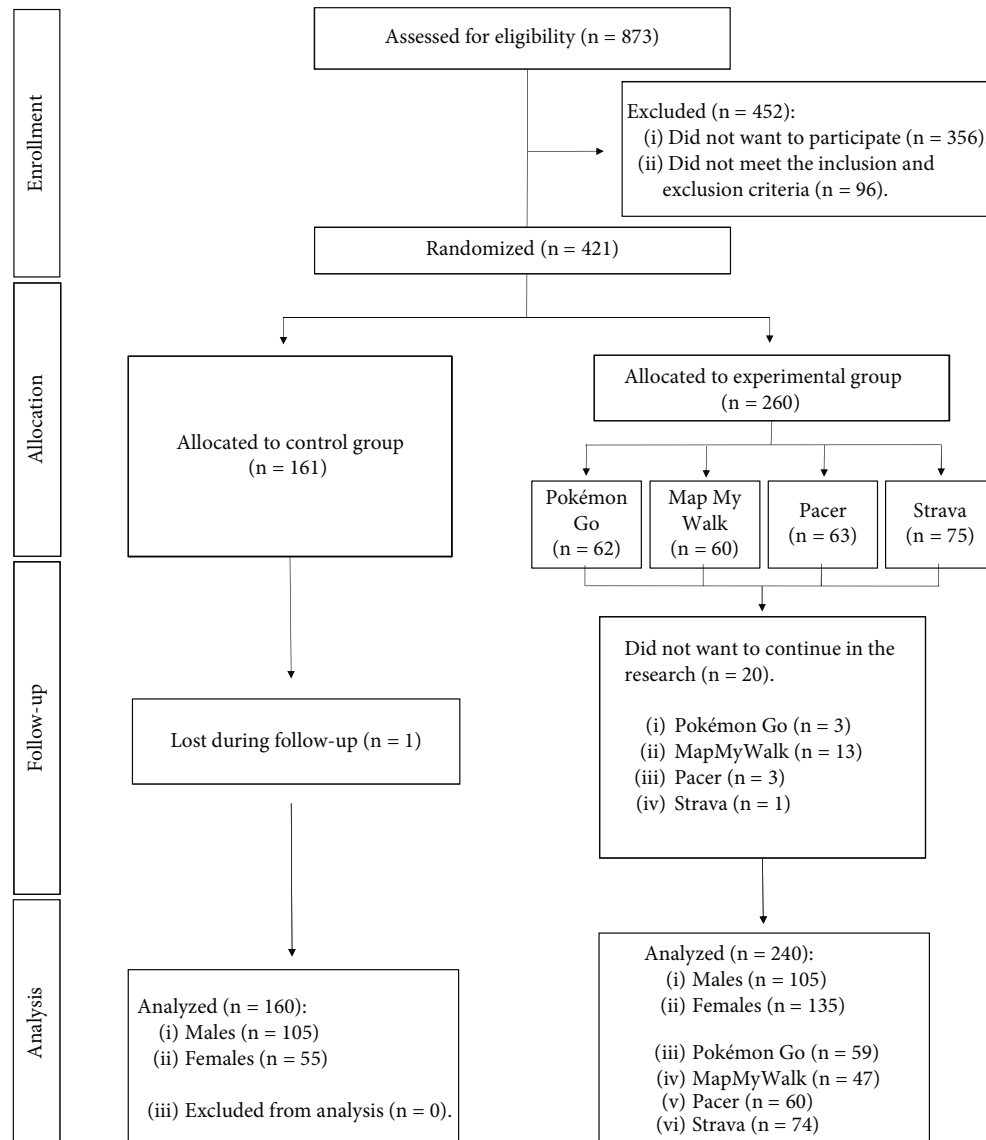


FIGURE 1: Sample selection flowchart.

randomizing, differences were found in the number of participants according to gender. Group assignment was blinded to the researcher responsible for assessing each participant's compliance with the inclusion and exclusion criteria. The inclusion criteria were (a) being in compulsory secondary education; (b) having no medical condition or illness that would prevent completing the questionnaires; (c) completing all the questionnaires; and (d) be present at the time of the assessments. The exclusion criteria included (a) missing more than 80% of the compulsory physical education classes; (b) not owning a mobile phone; (c) starting any new physical activity not practiced prior to the study, such as joining a sport or gym (with the exception of increased walking or running, as this was the focus of the research); (d) discontinuing any physical activity that was already being performed before the study; (e) change of school.

It should be noted that adolescents who did not meet the criteria for participation in the intervention (did not com-

plete the indicated weekly distance) were not excluded from their respective groups. They were given the post-test measurements and continued to be part of the n of the research.

2.3. Randomization and Blinding. After the recruitment and selection of the adolescents, meetings were held to explain the purpose of the trial and the randomization process to the teachers. The principal investigator carried out the randomization process with a computer-generated random number table, while other investigators, not involved in the study, were present. All students from the same class in each school center were allocated to the same mobile application group based on the randomization outcomes. The first randomization assigned each class to either the EG or CG, while the second randomization determined which mobile application would be used by the classes in the EG. The classes in the CG, similar to those in the EG, were instructed to carry on with their regular physical education sessions, with

the intervention being offered to CG students after the final data was collected. Baseline measurements were taken following the randomization. All meters were blinded to the participants' group allocations and their prior evaluations.

2.4. Instruments. The "Physical Activity Questionnaire for Adolescents" (PAQ-A) [70] was employed to evaluate adolescents' physical activity levels. This questionnaire was previously validated in Spanish [71]. It includes nine questions, with the first eight answered on a Likert scale ranging from 1 to 5 points, while the last question is answered with a yes or no response. The final score is calculated by averaging the scores of the first eight items [71]. A higher score in this indicates a greater practice of physical activity.

The Satisfaction With Life Scale (SWLS) [72] was used to assess the level of satisfaction with life. This scale consists of five items, each rated on a Likert scale from 1 to 5 points, resulting in a total score ranging from 5 to 25 points [73]. This scale has been translated into Spanish and demonstrated good internal consistency ($\alpha = 0.84$) for use with adolescents. A higher score in this indicates a greater satisfaction with life.

The BPNSs Scale [74] was used to evaluate adolescents' satisfaction with the three BPNSs (competence, autonomy, and relatedness). This scale is composed of 18 items (six for each dimension), each answered on a Likert scale ranging from 1 to 6 points, resulting in a final score between 6 and 36 points for each dimension [75]. The psychometric analyses conducted in previous research showed the adequate external validity and internal consistency of this scale (competence = 0.80; autonomy = 0.69; and relatedness = 0.73). A higher score in each category indicates a greater competence, autonomy, or relatedness.

The "questionnaire of experiences related to mobile phones" (CERM) was employed to evaluate problematic mobile phone use in adolescents [76]. The CERM consists of ten items, each rated on a Likert scale from 1 to 4 points, with a total score ranging from 10 to 40 points [76]. This questionnaire had been previously validated, showing a Cronbach's alpha of 0.80. The questionnaire makes it possible to differentiate between problematic use of mobile phones (score equal to or higher than 24), occasional problems (score between 16 and 23) and the absence of problems (score below 16).

2.5. Procedure. All the measurements were taken on the same day and during the physical education hour of each school group in both measurements (pre and post-test). The adolescents completed the PAQ-A, SWLS, BPNS, and CERM questionnaires randomly. The measurement conditions were similar for all the adolescents, as a school classroom in the education centers was used, where the adolescents were separated in order to be able to answer the questionnaires without pressure or surveillance, thus eliminating contaminating variables. They remained seated in a calm environment, without noise or distractions that could influence their answers. The researchers only helped to resolve possible doubts in the understanding of the questions, but in no case did they condition the adolescents' answers.

All measurements were blinded to both the participant's group assignment and their previous scores.

2.6. Mobile Application Intervention. For the development of the intervention, not only were the EG and CG randomized but also the mobile application to be used by each group. Once the application was known, a short explanatory session was held for each class, where information was given on how to register, how to use it, and how to visualize the distance per session and the final distance achieved.

Of the 400 adolescents that comprised the final sample, 240 used one of the four mobile apps selected for the research (Pokémon Go: $n = 59$; MapMyWalk: $n = 47$; Pacer: $n = 60$; Strava: $n = 74$). These apps were selected for having a high score in behavior change techniques, as shown in previous research [77], which made them good options for increasing the level of physical practice of adolescents. In addition, the fact that these are apps that have a simple interface for use by adolescents was another reason for selecting them.

Strava, Pacer, and MapMyWalk are three pedometers characterized because they allow recording the daily, weekly, and monthly distance performed, which allows teenagers to know their progress. However, Pokémon Go is a gamified app characterized by its playability. Adolescents walk around with the app open and find different Pokémon that they can catch. This gives this app a great incentive for its use. In addition, it allows to know the distance traveled with the use of the app.

The intervention was promoted by the physical education subject. The adolescents had to walk at least three times a week for 10 weeks during which the GE members used the mobile applications. Each week they had to walk the minimum distance indicated for each week. The initial distance (first week) each of the three times the app was used per week was 5000 steps per day (3.19 km, because 1 km is equivalent to 1565 steps) [78]. This is because 5000 steps, three times a week, is the minimum distance to stop being considered sedentary in adolescents [79]. So, the initial distance walked was 5,000 steps daily in the first week. The distance to be walked increased progressively each week (+700 steps daily each week), ending in the 10th week with a total of 12,500 steps in each of the three weekly sessions in which the adolescents used the mobile applications (37,500 steps in the last week). This distance was established according to previous research indicating that moderate to vigorous physical activity is associated in the adolescent population with achieving between 11,000 and 14,000 steps per day [80]. The CG ($n = 160$) did not use mobile activity-tracking applications in the after-school hours.

Following the methodology of previous research [52, 81], adolescents in the EG who did not complete the required weekly distance were not removed from their groups. They still underwent post-test measurements and remained part of the study sample.

2.7. Data Analysis. The normality of the data was analyzed using the Kolmogorov-Smirnov test, as well as skewness, kurtosis, and analysis of variance. Since all variables followed a normal distribution, parametric tests were employed for

analysis. Initially, student's *t*-test was conducted to assess baseline homogeneity between the EG and CG. Subsequently, a mixed factorial split-plot model analysis was performed to analyze intra and intergroup differences in the study variables. Significant differences between groups were further analyzed using the Bonferroni post hoc test. Partial eta squared (η^2) was used to calculate the effect size (ES) and was defined as small ($ES \geq 0.10$), moderate ($ES \geq 0.30$), large ($ES \geq 1.2$), or very large ($ES \geq 2.0$), with an error of $p < 0.05$ [82]. The covariate "mobile application used" was included to analyze the differences in the model. A linear regression analysis was carried out to analyze the predictive ability of physical activity level and mobile app use, on psychological variables and problematic mobile phone use. A *p* value of $p < 0.05$ was used to establish statistical significance. The SPSS statistical package was used for statistical analysis (V.25.0; SPSS Inc., IL).

3. Results

The baseline characteristics of the EG and CG can be found in Table 1. The analysis of the differences between the EG and CG at baseline showed homogeneity in the study variables: physical activity level (mean diff.: -0.087 ; $p = 0.209$), life satisfaction (mean diff.: 0.201 ; $p = 0.698$), competence (mean diff.: 0.254 ; $p = 0.658$), autonomy (mean diff.: 0.818 ; $p = 0.242$), relatedness (mean diff.: 0.627 ; $p = 0.194$), and mobile phone use (mean diff.: -1.214 ; $p = 0.070$). Although there were no significant differences at baseline in any of the variables analyzed, the level of physical activity and mobile phone use was higher in CG adolescents, while in the psychological variables, EG adolescents scored higher.

The increase in physical activity was significant between pre and postmeasurements in the EG (mean diff. (prepost): -0.170 ; $p < 0.001$), but not in the CG (mean diff. (prepost): 0.014 ; $p = 0.753$). The differences were significant in both males (mean diff. (prepost): -0.141 ; $p = 0.010$) and females (mean diff. (prepost): -0.192 ; $p < 0.001$) in the EG between pre and post-test.

Table 2 shows the intragroup differences in psychological variables and in problematic mobile phone use in the EG and the CG between pre and postmeasurements. The differences were significant in the CG in relatedness ($p = 0.023$) and life satisfaction ($p = 0.049$), with the score in both variables decreasing after the intervention with mobile applications. No significant differences were found in the rest of the variables. The covariate "type of app used" was not shown to significantly influence changes in psychological state or problematic mobile phone use between the pre and post-test in any of the groups.

The intragroup differences according to adolescent gender are shown in Table 3. It should be noted that the differences in relatedness ($p = 0.017$) and life satisfaction ($p = 0.044$) were significant in the females from the CG, with both variables decreasing significantly after the intervention, but not in the EG or in the males. No significant differences were found in the rest of the variables. Also, the covariate "type of app used" did not show any differences in either group, between the pre and post-test as a function of gender.

The intergroup differences in the psychological variables and in problematic mobile phone use are shown in Table 4.

TABLE 1: Baseline characteristics of the experimental and control groups.

Variables	Experimental group ($M \pm SD$)	Control group ($M \pm SD$)
Physical activity level	2.66 ± 0.63	2.73 ± 0.65
Life satisfaction	17.90 ± 4.61	17.69 ± 4.06
Competence	26.74 ± 6.74	26.50 ± 6.78
Autonomy	25.28 ± 5.92	24.45 ± 5.72
Relatedness	24.96 ± 5.94	24.33 ± 5.91
Mobile phone use	15.64 ± 5.34	16.96 ± 4.85

No differences were found at the beginning of the research (pre), but all study variables showed differences between the EG and CG at the end (post). Thus, the EG showed higher scores than the CG in competence ($p = 0.014$), autonomy ($p = 0.003$), relatedness ($p = 0.005$), and life satisfaction ($p = 0.036$). Similarly, the EG showed lower scores on problematic mobile phone use ($p = 0.004$) than the CG after the intervention. Thus, in most of the variables, there is an increase in the score in the EG and a decrease in the CG, except in relatedness where both groups show a decrease, but it is much greater in the CG. In addition, the covariate "type of app used" showed significant differences in autonomy ($p = 0.030$), relatedness ($p = 0.021$), and problematic mobile phone use (0.041), after the intervention.

Table 5 shows the intergroup differences according to the gender of the adolescents. Females showed significant differences in autonomy ($p = 0.010$), relatedness ($p = 0.019$), and life satisfaction ($p = 0.020$), while males showed significant differences in competence ($p = 0.018$) and relatedness ($p = 0.021$). In all the cases analyzed, the EG score was higher than that of the CG, increasing the score after the intervention in the EG and decreasing in the CG in all variables, except relatedness in which both groups decreased. Regarding the problematic mobile phone use ($p = 0.007$), the differences were significant only in females, with those in the CG showing higher scores than those in the EG. Regarding the covariate "type of app used", we observed an influence on autonomy ($p = 0.021$), relatedness ($p = 0.013$), and problematic mobile phone use ($p = 0.025$) in females, while in males, it only influenced relatedness ($p = 0.020$), after the intervention.

Table 6 shows the linear regression model of the psychological variables and problematic mobile phone use. It should be noted that the BPNS were predicted by physical activity level and app use ($p < 0.001 - 0.015$), while life satisfaction was only influenced by physical activity level ($p < 0.001$). Regarding problematic mobile phone use, app use was the only factor with a predictive capacity ($p = 0.003$). It should be noted that in all of these models, the predictive ability was low ($R^2 = 0.024 - 0.145$).

4. Discussion

4.1. *Use of Mobile Step-Tracking Apps and Their Influence on the Psychological State of Adolescents.* The first aim of the present research was to establish the differences in

TABLE 2: Differences in the psychological variables and problematic mobile phone use between the pre and post-test.

Variable	Group	Pretest (<i>M</i> ± <i>SD</i>)	Post-test (<i>M</i> ± <i>SD</i>)	Mean diff. (prepost)	ANOVA				ANCOVA with the type of app used as covariable			
					<i>p</i>	CI 95%	<i>η</i> ²	<i>p</i>	CI 95%	<i>η</i> ²	<i>p</i>	CI 95%
Competence	EG	26.09 ± 7.87	26.68 ± 7.19	−0.597	0.276	−1.672; 0.479	0.003	0.128	−2.553; 0.323	0.006	0.006	—
	CG	25.73 ± 7.80	24.70 ± 8.83	1.031	0.121	−0.272; 2.334	0.006	—	—	—	—	—
Autonomy	EG	24.68 ± 7.00	25.15 ± 6.76	−0.475	0.371	−1.516; 0.567	0.002	0.372	−2.028; 0.761	0.002	0.002	—
	CG	23.86 ± 6.65	22.87 ± 8.32	0.988	0.125	−0.275; 2.250	0.006	—	—	—	—	—
Relatedness	EG	24.43 ± 7.01	24.27 ± 7.21	0.164	0.753	−0.861; 1.189	0.001	0.747	−1.597; 1.146	0.001	0.001	—
	CG	23.51 ± 6.98	22.06 ± 8.45	1.444	0.023	0.202; 2.687	0.013	—	—	—	—	—
Life satisfaction	EG	17.48 ± 5.35	17.58 ± 4.93	−0.097	0.780	−0.778; 0.584	0.001	0.461	−1.253; 0.569	0.001	0.001	—
	CG	17.28 ± 4.69	16.45 ± 5.70	0.827	0.049	0.002; 1.652	0.010	—	—	—	—	—
Problematic mobile phone use	EG	15.59 ± 3.55	15.71 ± 4.30	−0.121	0.648	−0.642; 0.400	0.001	0.367	−0.999; 0.371	0.002	0.002	—
	CG	16.60 ± 4.88	17.15 ± 5.07	−0.550	0.198	−1.003; 0.308	0.003	—	—	—	—	—

Abbreviations: CG, control group; EG, experimental group.

TABLE 4: Differences in the psychological variables and problematic mobile phone use between EG and CG in the pre and post-test.

Variable	Measurement time	Experimental	Control	Mean diff. (prepost)	ANOVA			ANCOVA with the type of app used as covariable		
					p	CI 95%	η^2	p	CI 95%	η^2
Competence	Pre	26.09 ± 7.87	25.73 ± 7.80	0.354	0.658	-1.216; 1.923	0.001	0.739	-3.153; 2.240	0.001
	Post	26.68 ± 7.19	24.70 ± 8.83	1.981	0.014	0.400; 3.562	0.015	0.077	-0.267; 5.167	0.008
Autonomy	Pre	24.68 ± 7.00	23.86 ± 6.65	0.818	0.242	-0.556; 2.193	0.003	0.416	-1.385; 3.340	0.002
	Post	25.15 ± 6.76	22.87 ± 8.32	2.281	0.003	0.793; 3.769	0.022	0.030	0.275; 5.388	0.012
Relatedness	Pre	24.43 ± 7.01	23.51 ± 6.98	0.927	0.194	-0.475; 2.328	0.004	0.465	-1.512; 3.306	0.001
	Post	24.27 ± 7.21	22.06 ± 8.45	2.207	0.005	0.658; 3.756	0.019	0.021	0.478; 5.799	0.013
Life satisfaction	Pre	17.48 ± 5.35	17.28 ± 4.69	0.201	0.698	-0.818; 1.221	0.001	0.886	-1.879; 1.625	0.001
	Post	17.58 ± 4.93	16.45 ± 5.70	1.125	0.036	0.073; 2.177	0.011	0.128	-0.406; 3.210	0.006
Problematic mobile phone use	Pre	15.59 ± 3.55	16.60 ± 4.88	-1.010	0.070	-2.085; -0.343	0.020	0.058	-3.473; -0.522	0.009
	Post	15.71 ± 4.30	17.15 ± 5.07	-1.440	0.004	-2.416; -0.464	0.023	0.041	-3.382; -0.067	0.011

4.2. Gender Differences in the Influence of the Use of Step-Tracking Mobile Apps on the Psychological State of Adolescents. The second aim of the present research was to analyze the differences in the study variables after an intervention with mobile applications, according to the gender of the adolescents. The results showed that in the CG, females showed a significant decrease in relatedness and life satisfaction after the intervention, although no significant differences were found in the EG. In addition, females in the EG showed more autonomy, relatedness, and life satisfaction than females in the CG, while males in the EG showed more competence and relatedness than males in the CG. Regarding these differences, the results found in the males are in line with previous research, in which a physical activity program showed improvements in competence and relatedness, exclusively [12], which were justified by the improvement in intrinsic motivation for the practice of physical activity. For this reason, it would be appropriate for future research to analyze motivation as a fundamental variable for adherence to the physical activity program using mobile step tracker apps. As for females, the increase in autonomy and life satisfaction stands out, which could be related to the fact that the practice of physical activity is largely influenced by gender stereotypes, which exert a negative influence on the frequency and type of physical activity practice exercised by females [57]. In this case, the use of mobile apps would reduce the influence of these stereotypes, since the practice would not be subject to social validation, thus facilitating sports practice and the associated psychological benefits.

The fact that only females in the CG showed a higher problematic mobile phone use than females in the EG could be due to the fact that during adolescence, psychological variables evolve differently between males and females, with females presenting more internalization problems [59]. In this regard, the use of step tracker mobile apps could contribute to an adequate use of the mobile phones in females, with this being essential, as they are the ones who use digital technologies to a greater extent [89]. However, this use is mainly centered on accessing social networks [90], which are risky environments in which the psychological state can decrease due to the isolation produced [91, 92]. In addition, a distorted image of reality can be held in this environment, due to the images offered in them, which can generate a hostile environment for perceptions of self-image, which becomes more relevant due to the need for external approval (likes) for increasing self-esteem at these ages [93]. Therefore, the use of step tracker mobile apps could prevent, or at least reduce, the inappropriate use of mobile phones by females, but future research is needed to confirm these findings.

According to the results, the second research hypothesis can be confirmed because the females in the EG showed more autonomy, relatedness, and life satisfaction than the females in the CG, while the males in the EG showed more competence and relatedness than the males in the CG.

4.3. Influence of the Mobile Step-Tracking App Used on Changes in the Psychological State of Adolescents. The third aim of the present research was to determine whether the different mobile applications used had an influence on the

differences in the study variables. In this regard, the inclusion of the covariate “type of app used” was shown to be relevant in the autonomy, relatedness, and problematic mobile phone use of females, and in the relatedness of males. No previous research is known to have analyzed the use of different mobile applications and their different influence on the psychological state of the adolescent population. Therefore, this is a novel aspect of the present investigation, and it may be due to the fact that the applications used different interfaces that offered different options. Some of the step trackers allow the creation of a community within the app [94], which could favor relatedness, while others allow the user to design the training, which could influence autonomy. At the same time, it is important to know that these apps not only connect to social networks, which increases their use [95] but could also increase problematic mobile phone use. However, future research is needed in this area to learn more about the influence of different mobile applications created to increase physical activity, on the psychological variables of adolescents.

One aspect that cannot be overlooked in this research is that the analysis of the covariate “app used” was significant in autonomy, relatedness, and problematic use of the mobile phone. This could be because each of the apps offers different possibilities of operation and some of them allow generating groups or challenges within the app, which could be key in the change produced in the psychological variables.

The third research hypothesis can be confirmed because the inclusion of the covariate app used showed significant differences in autonomy, relatedness, and problematic mobile phone use.

Nevertheless, it is important to highlight the results obtained in the linear regression analysis performed. The level of physical activity and the use of mobile applications were shown to be predictors of BPNS. However, life satisfaction was influenced only by the level of physical activity, while problematic mobile phone use was predicted only by the use of mobile applications. Furthermore, the predictive ability of psychological variables and problematic mobile phone use by physical activity level and mobile app use was very low. This indicates that further research is needed to explore which are the most determinant factors that may affect psychological variables in the adolescent population.

4.4. Limitations and Strengths of the Research. The present investigation is not free of limitations. Firstly, it would be appropriate to assess the motivation with which the adolescents begin and end the intervention. This variable is related to those analyzed in the present study and could be a key factor to be considered when trying to explain the changes observed in the psychological state of the adolescents. Secondly, the comparison of the differences in the study variables according to the mobile application used should be considered in future studies, as significant differences were found in the present investigation when this covariate was introduced. Thirdly, it was not assessed whether adolescents used the app for fun, to compete, to earn a grade in physical education subject, or whether the fact that apps like

Pokémon Go were gamified also influenced their use of the app. Fourthly, the use of questionnaires alone is a limitation to be considered as they provide limited information on the variables being measured. For this reason, it would be important for future research to complement this information with qualitative methods such as interviews or focus groups on which more information can be obtained. Fifthly, the use of a self-report measure to assess the level of physical activity is another limitation to be considered, as it is the adolescents who assess the perceived change in the level of physical activity. The cost of the devices needed to assess physical activity objectively and the large sample included in this research are both explanations for this, so future research should try to include these devices to really know the changes in physical activity levels after the intervention.

Despite the limitations, the present research shows the benefits that the use of mobile applications in the school environment can have for the improvement of the psychological state of adolescents. The practical applications of the same refer to the usefulness that the inclusion of mobile applications of physical activity in the physical education subject in schools can have. Previous research in this field has shown the benefits of the same in the level of physical activity, physical condition, and body composition, and the present research provides information on the benefits in the psychological domain. Furthermore, despite the use of the mobile phone for intervention monitoring, no increase in problematic use of this device was found, so it could be a suitable tool for use in the educational setting. However, future research that analyzes the factors that are more directly related to such problematic use is needed. However, this is the first investigation in this regard, and future research should, therefore, delve more deeply into the possibilities that these devices offer in the educational setting to promote the health of this population.

4.5. Implications for Practice and Future Studies. In light of the results obtained in this research, future lines of research should include the analysis of the changes in the psychological state that can be produced by different types of mobile applications, both gamified and nongamified. In addition, further research is needed on the importance that physical activity and the use of mobile applications can have on the psychological state of adolescents, including important variables such as anxiety, stress, or motivation for the use of applications. In this way, it will be possible to go deeper into a field that is still developing and whose results may be of great importance for promoting adolescent health. In addition, future research in the educational setting that addresses psychological variables and, more specifically, SDT should consider the recently published classification system for teachers' motivational behaviors [96], as it would facilitate the understanding of the real effectiveness of interventions in this area. In future research with mobile apps of longer duration, it would be useful to include a midintervention measurement after the first few weeks, as this is when there is greater engagement with the intervention, and there could be significant differences compared to the final part where there may be a loss of adherence.

Due to the influence that mobile applications seem to show on psychological state, future research in the field of

app programming and design could benefit from the following: (a) adding a section within the app to track and record some psychological variables that are considered relevant. This information will not be available to other users, only to authorized users. This will allow real-time data collection and comparison of the effects of the intervention carried out. To this end, a section could be included in the app that allows researchers to upload questionnaires or ask users questions about their psychological state once the physical activity is over. This would prevent the psychological information from being biased because users give their opinions at the time of the measurements and do not remember their true psychological state when they were using the app. This can be very useful and beneficial for researchers, helping them to store data and expand sample sizes, as seen in previous research [97]; (b) inclusion of this type of information would make it possible to unify the instruments and methods used for data collection, which would make it possible to obtain much larger samples that have used the same mobile applications and completed the same questionnaires. This would solve one of the main problems of previous research, in which the existence of numerous methods for measuring the same variable led to difficulties in terms of comparison and selection, with the least optimal option sometimes being chosen [98]. This occurs in this area when selecting questionnaires that are not valid or reliable for what is intended to be recorded; and (c) the inclusion of a complementary technological device such as a sensor or bracelet that would help measure changes in the psychological state of the subjects through changes in other physiological parameters such as heart rate or other chemical markers of the skin could also be considered [99].

5. Conclusions

From the present investigation, it can be concluded that the use of mobile applications in the adolescent population has beneficial effects on their psychological state (BPNs and life satisfaction). These benefits are not so much due to a substantial improvement in the EG, but rather to a maintenance, compared to the CG that decreased the score in these variables after the intervention. Particularly noteworthy is that the use of different applications could have a considerable impact on changes in psychological state, but this needs to be corroborated in future research. Furthermore, the changes in psychological variables seem to be mainly influenced by the improvement in the level of physical activity achieved with the apps, and, most relevantly, there is no increase in the negative use of the mobile phone after the intervention. However, these results should be corroborated in future research that considers motivational aspects and analyzes the motives that led adolescents to use the apps.

Data Availability Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Disclosure

This work is part of the doctoral thesis of Adrián Mateo-Orcjada.

Conflicts of Interest

The authors declare no conflicts of interest.

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