Citation for published version:

Gutiérrez-Santiago, A., Paramés-González, A., & Prieto-Lage, I. (2022). Effect of Teaching Method on Exercise Execution in Adolescents' Use of Outdoor Fitness Equipment. Perceptual and Motor Skills, 129(4), 1302-1320. https://doi.org/10.1177/00315125221098635

Peer reviewed version

Link to published version: https://doi.org/10.1177/00315125221098635

Effect of Teaching Method on Exercise Execution in Adolescents' Use of Outdoor Fitness Equipment

Abstract

The use of outdoor fitness equipment (OFE) is an effective strategy to promote physical activity. The equipment normally includes information panels with phrases and images describing appropriate exercises. However, as using this equipment inappropriately is a potential problem, it is important to find an optimal unsupervised instruction method for correct exercise execution. Our objective in this study was to determine which of several exercise prescription methods, without direct professional supervision, might best instruct adolescents to correctly engage in upper limb motor execution on outdoor flexion-extension equipment. A total of 54 adolescents from a middle socioeconomic level in northwest Spain participated in this descriptive and quasi-experimental study. We randomly assigned members of this convenience sample into three groups who received either video instruction, instruction via images or written panel instructions. We used observational methodology in videographic analysis to evaluate the mistakes participants made in motor execution with each instructional method. We utilized different analytic techniques from observational methodology: statistical analyses (means, standard deviation, confidence intervals, ANOVA, etc.) and detecting T-Patterns with Theme and polar coordinate analysis using HOISAN. Participants who relied on video instructions committed fewer errors than those who relied on panel instructions. The video method prevented loss of information that occurred when instructional images were used. We suggest including a QR code on outdoor fitness equipment in open-air parks to permit users to download an explanatory video to their mobile phones.

Keywords: Outdoor Fitness Equipment; teaching method; error; T-Pattern; observational methodology

Introduction

The World Health Oganization claimed that 81% of school aged children and adolescents are insufficiently active (WHO, 2010), and an associated rise in obesity has become a global epidemic during the 21st century. Therefore, experts have recommended improving children's physical activity habits to prevent disease and promote health. A possible solution is provided by the ecological model (Sallis et al., 2008) which suggests that the environment built in cities influences the practice of physical activities. Therefore, positive associations between improved physical activity and accessibility to outdoor spaces ar likely (Lestan et al., 2014). Outdoor fitness equipment (OFE) provides free public access to exercise outdoors with training equipment that is focused on different muscle groups. A systematic review has determined that participants have used OFE to pursue better health, weight reduction, and muscle strengthening (Lee et al., 2018). As OFE is usually located in convenient parks that allow adolescents to move freely without adult supervision, it should help address worrying trends toward more sedentary lifestyles (Carver et al., 2010).

A study of obesity (WHO, 2020) in children and adolescents showed alarming figures, with an incidence of more than 24 million (6% of girls and 8% of boys) in 2016, leading to recommendations to incorporate vigorous-intensity aerobic activities at least three days a week. Developing more OFE is an effective strategy for promoting physical activity, as it significantly increases the level of physical activity among adolescents (Cranney et al., 2016). A park is visited more often by adolescents when it has OFE (Van Hecke et al., 2018), but an obstacle in OFE usage is inadequate information on how to execute the exercises (Lee et al., 2018). Most OFE provides informative instructional panels with descriptive phrases and images about the exercise that can be performed on each piece of equipment. However, users have demanded more help on how to exercise their body and at what pace and intensity they should engage in these exercises (Chow et al., 2017). Since OFE is located in outdoor parks without the permanent presence of a supervising instructor to explain the exercises (Lee et al., 2018), it is necessary to develop an optimal instructional method for explaining proper OFE use. In the absence of prior research analyzing which explanatory method may be best for detailing correct OFE use, we sought to compare OFE instructional methods.

There are multiple means of assessing the execution of OFE based exercises and the effectiveness of their varied instructional models that may be static (e.g., images and photographs) or dynamic (e.g., audio or video). Motor learning (acquisition and memory) and motor performance has been found to be executed significantly better from dynamic than static instructional models (Weeks et al., 2002). Considering that (a) 92.8% of adolescents have had access to smartphones since they were 14 years old (Spanish National Institute of Statistics, 2017), (b) mobile technology has been favorably received in various healthcare interventions (Padmasekara, 2014) and (c) there has been a call to review the marketing of OFE to attract new users (Cohen et al., 2012), we considered the use of mobile devices and video instructions to explain exercises on OFE to be a novel, appropriate, scalable and motivating instructional model for adolescents (Blackman et al., 2016). Accordingly, our objective in this research was to determine which instructional method for OFE exercises without direct professional supervision would achieve the most correct motor execution of upper limb OFE flexion-extension equipment by adolescents. We formulated the following research hypthotheses: (a) different instructional methods for OFE exercise would differentially influence the number of mistakes made in motor execution; (b) there would be specific patterns of mistakes associated with certain instructional methods; and the best instructional method would be the one that utilized video.

Method

Research Design

This was a descriptive and quasi-experimental study that relied on a convenience sample of adolescents who were randomly distributed into three groups. Each group was given a distinct instructional method for executing an upper limb flexion-extension exercise using OFE. We assessed the level of learning achieved by participants by determining the mistakes participants made in each execution from observational methodology (Anguera et al., 2018). Our observational design (Anguera et al., 2011) was nomothetic (several participants executed the same exercise), punctual (in a single session), and multidimensional (measured dimensions corresponded to the criteria of the observation instrument). From this design, we could derive a series of decisions about the participants, the instruments we used, and the analytic procedures.

Participants

Participants were 54 adolescents (26 females, 28 males; *M* age = 15, *SD* = 1 years), from a middle socioeconomic level attending high school in northwest Spain. We randomly assigned them into three groups of 18 participants each: (a) Group 1: video instruction; (b) Group 2: instruction by written information panels; and Group 3: instruction by images. Participant inclusion criteria were: (a) students in a high school physical education class; (b) not suffering from an injury or medical contraindication that prevented them from taking the exercise test; and (c) having received no previous training on the OFE.

Prior to conducting this research, we received authorization to perform the data collection tasks from the center's management team. We then informed all families and research participants of the objectives of the study, and we obtained written informed consent from parents or legal guardians of all participants and assent from all participants. The ethical principles of medical research involving human subjects set forward in the Declaration of Helsinki (Harriss & Atkinson, 2015) were respected at all times. The study protocol was approved by the ethics committee of the Faculty of Education and Sport Sciences of the University of Vigo with code the 10-0121.

Developing an Exercise Instruction Model

We reviewed the databases and documents of the construction company that manufactured the OFE in our search for an ideal technical model of how to perform the exercise for which the equipment was designed. Finding no such exemplary model, we created these instructions ad hoc*,* while considering the content of the exercise informative panel on the OFE. We also considered other technical models of how to conduct similar exercises of flexion-extension of the upper extremities: push-ups in a horizontal plane or with support in a vertical plane. After creating an ideal instructional model, we validated the model with reviews from three experts (university professors in the field of health and sports training). Once the experts' suggested corrections were implemented, the execution of this exercise was characterized as cyclic from an initial position into three differentiated phases of movement (see Figure 1):

1. Initial position (position 1): upright participant with the body parallel and close to the equipment; hands are gripped around the handles; elbows are flexed at 135º.
2. Phase 1 (eccentric phase): this phase goes from position 1 to position 2. The angulation of the elbow joint of 135º in flex is modified to about 30º in extension.
3. Phase 2 (isometric phase): the participant remains in position 2 (transition between the eccentric and concentric phases).
4. Phase 3 (concentric phase): this phase goes from position 2 to position 3. The articulation of the elbow evolves from 30º in extension to 135º in a flex.

[Insert Figure 1 about here.]

Observational Measurement

The observational measurement instrument we developed ad hoc for this study was designed as an Instrument to Observe Upper Limb Flexion-Extension - IOUPPERLIMB_FLEX-EXT- (see Table 1). It combined the field format with the category system (Gutiérrez-Santiago et al., 2011) and consisted of several criteria that allowed us to use it to determine the participants' mistakes in executing the exercise. This instrument met the conditions of thoroughness and mutual exclusivity. Validity of its construct was demonstrated through its coherence with the theoretical framework (ideal technical model) and its consultative review by three experts (the same ones who validated the ideal technical model) who showed their agreement (92%) with the instrument. All the participants' observed behaviors on the observation instrument were codified and registered by LINCE software v.1.2.1 (Gabin et al., 2012).

[Insert Table 1 about here.]

Procedure

The 54 adolescent participants were divided into three groups of 18 participants each, and each group experienced a different teaching method for OFE instruction. Group 1 viewed a video showing a person as a model performing the movements of the exercise on the OFE. Group 2 read an informative panel of written instructions for the OFE, including an image of the equipment, a title that identified the exercise, as well as a text with key aspects of the OFE use for executing the exercise. Group 3 saw a series of static color images (positions 1, 2 and 3 of Figure 1), extracted from the video, to ensure their same execution of the model instructions. Below each of the images that Group 3 saw there was a description of the exercise in the information panel.

Each participant individually received researcher instructions according to their assigned teaching method. Afterwards, a separate, private recording was made, so that all images, instructions on the information panel, or video content and the participant's execution of the exercise were out of sight of other participants. A Sanyo Xacti model VPC-CA9EX video camera was used for the recordings. The camera was placed in a perpendicular position with respect to the movement performed by the participant, three meters away, next to where another researcher was standing.

The participants executed the exercise autonomously and without supervision after receiving the instructional information. They could not practice the movement while they learned it. The time available for learning the movement was the same across all groups, as defined by the 20 seconds duration of the Group 1 video. At the end of this time, no additional participant questions or clarifications were allowed, and participants undertook three consecutive repetitions of the exercise. We selected the second repetition for data analysis to minimize any effect associated with the beginning or end of the action effort (Reo & Mercer, 2004).

Before proceeding with listing the errors in the recordings, our observers underwent training with the observation instrument. During this process, each researcher observed 15 video parts, five from each group (video, panel, and images) of participants who were not part of the final sample. Subsequently, we analyzed intra-observer and inter-observer kappa coefficients and found intra-observer concordance to be 0.95 for observer 1 and 0.96 for observer 2. The inter-observer concordance was 0.92. After passing these quality tests, these two researchers, experts in observational methodology, recorded the data from the participants' second trial using the IOUPPERLIMB_FLEX-EXT instrument.

We achieved data quality (Blanco-Villaseñor & Anguera, 2000) with a single register through two observers who discussed among themselves and came to a consensus regarding which data category to assign to each behavior. After data registry, we used an Excel file to enter the sequence all the codes of the registered behaviors. The versatility of this file allowed us to make successive transformations for the different analyses.

Data Analysis

We calculated descriptive tests of the data to derive group means, standard deviations, and confidence intervals. To determine differences between the groups, we used analyses of variance (ANOVAs). We tested the normality of the data distribution with the Komolgorov-Smirnov test and homoscedasticity compliance by means of the Levene test. If there was normality and homoscedasticity, we planned to use the Bonferroni post-hoc test; and if these assumptions were not met, we planned to use the Games-Howell post-hoc test. All analyses were carried out with the Statistical Package for the Social Sciences (SPSS, v. 20.0; IBM Corporation, New York). We generally established $p < .05$ as the level of significance. However, to identify the mistakes sequence we calculated T-Patterns with Theme v.5.0 software (Magnusson et al., 2016) and used a significance level of $p < .005$ (the percentage of accepting a critical interval due to chance is 0.5%). For these error analyses, we set a minimum number of occurrences of three, not discarding occurrence patterns equal to or greater than three. This software reveals hidden structures and unobservable aspects of motor behaviors and it has also been extremely effective in analyzing motor behavior (Magnusson et al., 2016). We calculated the polar coordinates with the HOISAN software program (Hernández-Mendo et al., 2012) using Sackett (1980) analytical technique in the genuine retrospective variant (Gorospe & Anguera, 2000) previously used in numerous past studies (e.g., Tarragó et al., 2017). We considered the relationships between focal behavior and conditioned behaviors statistically significant when the length of the vector was greater than 1.96 ($p < .05$).

Results

Participants' descriptive characteristics and group differences are shown in Table 2.

[Insert Table 2 about here.]

The group of participants who watched the video made the fewest errors (*M* = 3.94, *SD* = 2.89). The group that made the highest number of errors was the group that used the panel as a learning method (*M* = 19, *SD* = 9.70) followed by the group that used the image method (*M* = 12. *SD* = 3.80). The mistakes made by participants in the starting position were not distributed normally, because these mistakes were only made in the panel group. This explains the significant differences between the methods that used the panels and the other two methods.

We observed significant group differences ($F(2,51)=15.635$, $p<0.001$) in the errors made in the upper extremity between the different groups analyzed (video, panel and images). Differences occurred between the video method with respect to the other two, but there were no differences when comparing the panel method with the image method. The same occurred when analyzing the errors made in the rachis ($F(2,51)=7.792$, $p=0.001$), in the lower limb ($F(2,51)=8.443$, $p=0.001$) and in the speed of movement execution ($F(2,51)=15.308$, $p<0.001$). Based on a comparative analysis of the total sum of errors, we found significant differences ($F(2,51)=26.171$, $p<0.001$), with signficiant pairwise differences between all paired methods. Table 3 shows both a descriptive analysis of the errors detected as a function of body zone and group (video, panel or images) and the most relevant T-patterns found as a function of group.

[Insert Table 3 about here.]

Analysis of Errors in the Video Group

Instructional video was the teaching method that produced the fewest participant mistakes. The most frequent mistakes were insufficient shoulder extension (ISExt), full elbow extension (FEExt), poor grip on the apparatus (GH), omission of the isometric phase of the movement (NOIP), greater than recommended shoulder flexion (USFlex) and elbow flexion (UEFlex). The analysis of T-Patterns determined the mistake patterns among participants who watched the video, and Figure 2A indicates that when the participant performed the error wrist abduction-adduction (WAAbd) when gripping the equipment, there were errors of incomplete shoulder flexion (ISExt) and a greater elbow flexion (UEFlex) for 67% of participants (Table 3, I.2).

[Insert Figure 2 about here.]

We also found that when participants performed an elbow extension greater than reccomended (USFlex), this caused a full elbow extension (FEExt) that might lead to a participant's joint damage (Table 3, I.3). Polar coordinate analysis revealed that the absence of the isometric phase favored the cervical flexion (Figure 2D1).

Analysis of Errors in the Images Group

The teaching method based on images displayed produced a greater diversity of mistakes, and more mistake patterns. With this instructional method, more than 70% of the partipants used a poor grip on the apparatus (GH), omitted the isometric phase of the movement (NOIP), and engaged in upper shoulder flexion (USFlex) and full elbow extension (FEExt). Also, with this instructional method (Table 3, I.4-5) we verified that an inssuficient shoulder extension (ISExt) produced an elbow extension greater than recccomended (UEFlex). Moreover, we also detected an opposite pattern, in that the upper shoulder extension (USFlex) led to a full elbow extension (FEExt). This last relationship was evident in 80% of the participants and was the consequence of a previous incorrect grip on the apparatus (GH) (Table 3, I.6). Mistakes in the upper limb (WFExt, ISExt and UEFlex) caused a forced position that triggered mistakes in other body areas, including excesive cervical

(CFlex), dorsal (DFlex) and knee (ADFlex) flexions, due to the incorrect support of the feet (Table 3, I.7).

The cervical and dorsal areas of the back worked together, so that of the 22 times that excessive cervical flexion occurred (CFlex), there was also an upper dorsal flexion (DFlex) wider than recommended with 82% frequency (Table 3, I.9). For 39% of participants, this excessive cervical (CFlex) and dorsal (DFlex) flexion was a consequence of an upper elbow flexion greater than required (UEFlex) (Table 3, I.10). In addition, this sequence of errors was accompanied by an incomplete shoulder extension (ISExt) that would condition the participant's position in executing the movement in 86% of the cases. (Table 3, I.11). Aspects that are specified in the polar coordinate are shown in Figure 2D2. An incorrect position of the feet on the apparatus (ADFlex) affected the kinetic chain of the movement producing a hyperkyphosis in 85% of the cases (DFlex) (Table 3, I.13). This relation could also occur in the opposite direction. The height of the grip performed on the apparatus (GH) produced errors in the angles of shoulder extension (ISExt) and elbow flexion (UEFlex) (Table 3, I.17), leading to the shoulder working at incorrect flexion angles (USFlex) in the second phase of the movement in 83% of the cases (Figure 2B), as well as locks in the elbow when performing a full extension (FEExt). Similarly, incorrect wrist positions when gripping the apparatus (WFExt) conditioned the participant's position, producing dorsal flexion (DFlex) on 13 occasions (Table 3, I.14), which resulted in an incomplete shoulder extension (ISExt) in 69% of the cases (Table 3, I.15). Finally, the omission of the isometric phase (NOIP) caused incorrect ranges of motion in the shoulder (USFlex) and elbow (FEExt) in the second phase of the exercise up to 13 times (Table 3, I.22).

Analysis of the Panel Group

The most frequent error when using the information panels was the incorrect starting position (IncSP). With the information from the panel, 77.7% of the participants adopted an incorrect position after an inadequate interpretation of the movement they had to perform. Therefore, they could not be evaluated following the designed observation instrument, and it became impossible to detect mistake patterns. We conducted the calculation of T-Patterns on the remaining participants (22.3%). Although the general execution of the exercise allowed its analysis, the pattern that occurred in all the cases analyzed (Table 3, I.25) led to an indentification of errors in practically all the criteria studied: feet (SOTG), knees (APFlex), lumbar spine (LFlex), elbow (FEExt), shoulder (USFlex) and omission of the isometric phase (NOIP). Figure 2C shows the sequence of errors described above.

Discussion

In this study of different instructional methods for the use of OFE equipment by Spanish adolescents, we found that the participants who used the video always obtained a lower frequency of mistakes in the different parts of the body (almost four mistakes per person). In addition, we found fewer error patterns in this condition than in other methods of instruction, and there was no clear relationship between the errors detected. In contrast, participants who experienced the other two instructional methodologies relying on instructional images (12 errors per person) and text information in instructional panels (19 errors per person) made significantly more exercise execution mistakes. Therefore, two premises of this research were confirmed: the teaching method influenced the number of mistakes made, and the most appropriate method was the one that usesd video. These results are in line with other research indicating that manufacturers should provide clear equipment operation guides and that video-based instructions should include relevant information directed to the OFE user for correct performance of the exercise (Weeks et al., 2002; Chow et al., 2019).

It is important to acknowledge that the participant mistakes that were associated with the articulation of the wrist in many cases occurred because the OFE equipment was not adjustable. This fixed equipment produced these mistakes when the person gripped around handles that ended up in a low position in relation to their height. OFE manufacturing companies should redesign equipment to allow users to regulate and adjust the equipment to their own anthropometric characteristics. (Abelleira-Lamela et al., 2021; Chow et al., 2019; McGill et al., 2014).

The body area where the highest number of errors were recorded, regardless of instructional method, was the upper limbs. A common pattern of errors was that the participant's shoulder was insufficiently extended, causing the elbow to flex more than necessary creating a forced position. This relation between behaviors was a consequence of a previous adduction-abduction in the wrist that affected the entire kinetic activity chain (Imagama et al., 2014). A situation that should be avoided is a greater than ideal shoulder angulation. This usually produced a full extension of the elbow on which the full weight of the body rested, possibly causeing an injury (Kuzala & Vargo, 1992).

Grip height was a fundamental aspect of OFE use, because the movement of the upper extremities depends on where we make this grip. In the group receiving instructional images, this mistake triggered numerous mistake patterns that led to various other dmistakes of the upper limb. The grip mistake implied related mistakes in the angulation of the joints in all phases of the movement, and it modifyied the neutral position of the wrist joint, generating wrist errors. Due to the high number of errors related to the upper limbs, OFE manufacturers should emphasize explanations of this body segment in their instructions for this equipment. (Chow et al., 2019).

Attention should also be paid to spinal errors. Another study that analyzed other OFE devices and their information panels also found that, in exercises in which participants were standing, significant misalignments were made in the spine, increasing the risk of future injury

(Abelleira-Lamela et al., 2021). There are numerous mistake patterns associated with the spine because it functions as a unitary structure (Panjabi, 1992). This mistake pattern, in addition to modifying the neutral position of the spine, decreases the articular ranges of the shoulder, modifying the biomechanics of movement (Imagama et al., 2014). The support of the feet on the device is also key; and, for this reason, in the images instructional method, a poor support in the feet led to a modification in the participant's posture and an altered alignment of the dorsal spine (Ebenbichler et al., 2001).

Anther remarkable observed error was the absence of an isometric phase. This mistake is associated with a lack of control in the movement, creating an abrupt transition from the eccentric to the concentric phase (Søgaard et al., 1996). Additionally, this error leads to a loss of the spine's vertical alignment. This mistake was observed to a greater extent in the group who used instructional images. In this instructional method, images were presented in initial, intermediate and final positions, but participants could not observe the complete execution of the three phases and lost information about the whole movement (Miller et al., 2009). In the video method this type error did not occur, possibly because the video provided global information about the whole movement (Kingston et al., 2014).

A very relevant error pattern observed in this research began with errors related to the starting position. This mistake implied an incorrect position of the participant for the execution of the exercise, and it happened when participants did not understand the information provided and positioned themselves incorrectly by making a different movement. This mistake occurred only in the group who experienced textual instructional information panels, and it was recorded in more than 77% of these participants. This error percentage was higher than the 50% error rate reported in a study that analyzed user behaviors on other OFE in Taiwan (Chow et al., 2019). We conclude that information provided by the panels is most likely to be insufficient and lead to misunderstandings. This circumstance confirmed another premise of the research that there are specific mistakes and mistake patterns associated with a certain teaching method.

This finding gives rise to a concern that the panel instructional method (currently the most widespread) was incomprehensible to more than three quarters of the population we analysed and that the remaining participants made the highest frequency of errors. The small group of participants who could be analyzed with this teaching method showed errors in the entire movement sequence. Therefore, when following the panel method, the objectives of the exercise were not achieved, as the movement that users demonstrated was completely different from the one sought with the equipment, and accidents might occur due to OFE misuse (Reo & Mercer, 2004; Chow et al., 2017). Finally, considering that 92.8% of adolescents have cell phones from the age of 14 (Spanish National Institute of Statistics, 2017) and that videos were the best method to introduce comprehensible instructions for the execution of the exercise movement we studied, we propose that OFE devices include a QR code (Quick Response barcode) through which an explanatory video can be played on the cell phone (Ahmed & Zaneldin, 2020).

Limitations and Directions for Further Research

The sample size used in the study was small, limiting broad generalization of these results. This research should be replicated with a larger and more heterogeneous sample that would allow comparative analyses of sex and/or other subgroups when applying different teaching methods. Another study limitation was our analysis of a single OFE apparatus and associated exercise. Future investigators might apply this methodology to other equipment. The analysis of the rest of other apparatus would allow us to optimally understand different movement errors and error sequences generated to improve instructions and features of different apparatus.

Conclusion

We found video-based instructions for unsupervised OFE to be the most appropriate instructional delivery method. In our sample of Spanish adolescents, the video-based instructional model resulted in fewer OFE execution errors and safer equipment usage than instruction via either panel text or a presentation of exercise images. The panel method currently used for OFE was completely inadequate because it produced the greatest number of errors. Most of the participants who read these instructions on the information panel did not understand the exercise, and they carried it out with a totally different movement than our experts determined to be ideal. Participants using the images method of instruction omitted phases of the movement, as they did not receive complete information. In contrast, the video instructions provided a global vision of the exercise and avoided loss of information. In the movement of flexion-extension of the upper extremities, there were some key mistakes that shoud be avoided because their occurrence precipitated a chain of mistakes. The participant's starting position is fundamental because the height of the grip and the position of the feet can trigger mistakes in the angulation of the joints. We assert from these data that the use of a QR code for instructions on OFE that users can then download and view via video is both practical and advisable.

Declaration of Conflicting Interests

The Authors declares that there is no conflict of interest.

References

Abelleira-Lamela, T., Vaquero-Cristóbal, R., González-Gálvez, N., Esparza-Ros, F., Espeso-

García, A., & Marcos-Pardo, P. J. (2021). Sagittal spine disposition and pelvic tilt during outdoor fitness equipment use and their associations with kinanthropometry proportions in middle-aged and older adults. *PeerJ*, *9*, e12657. https://doi.org/10.7717/PEERJ.12657

Ahmed, W., & Zaneldin, E. (2020). Blending QR code with video learning in the pedagogical process for the college foundation level. *Interactive Technology and Smart Education*, *17*(1), 67–85. https://doi.org/10.1108/ITSE-08-2019-0043

Anguera, M. Teresa, Blanco-Villaseñor, A., Losada, J. L., & Portell, M. (2018). Guidelines for designing and conducting a study that applies observational methodology. *The UB Journal of Psychology*, *48*(1), 9–17. https://doi.org/10.1016/j.anpsic.2018.02.001

Anguera, M.T., Blanco-Villaseñor, A., Hernández-Mendo, A., & Losada-López, J. L. (2011). Observational designs: Their suitability and application in sports psychology. *Cuadernos de Psicología Del Deporte*, *11*(2), 63–76.

Blackman, K. C. A., Zoellner, J., McCrickard, D. S., Harlow, J., Winchester III, W. W., Hill, J. L., You, W., & Estabrooks, P. A. (2016). Developing Mobile Apps for Physical Activity in Low Socioeconomic Status Youth. *Journal of Mobile Technology in Medicine*, *5*(1), 33–44. https://doi.org/10.7309/jmtm.5.1.6

Blanco-Villaseñor, A., & Anguera, M. T. (2000). Evaluación de la calidad en el registro del comportamiento: Aplicación a deportes de equipo. In E. Oñate, F. García-Sicilia, & L. Ramallo (Eds.), *Métodos Numéricos en Ciencias Sociales* (pp. 30–48). Centro Internacional de Métodos Numéricos en Ingeniería.

Carver, A., Timperio, A., Hesketh, K., & Crawford, D. (2010). Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk? *Social Science and Medicine*, *70*(11), 1799–1805. https://doi.org/10.1016/j.socscimed.2010.02.010

Chow, H. W., Mowen, A. J., & Wu, G. L. (2017). Who is using outdoor fitness equipment and how? The case of Xihu Park. *International Journal of Environmental Research and Public Health*, *14*(4). https://doi.org/10.3390/ijerph14040448

Cohen, D. A., Marsh, T., Williamson, S., Golinelli, D., & McKenzie, T. L. (2012). Impact and cost-effectiveness of family Fitness Zones: A natural experiment in urban public parks. *Health and Place*, *18*(1), 39–45. https://doi.org/10.1016/j.healthplace.2011.09.008

Cranney, L., Phongsavan, P., Kariuki, M., Stride, V., Scott, A., Hua, M., & Bauman, A. (2016). Impact of an outdoor gym on park users' physical activity: A natural experiment. *Health and Place*, *37*, 26–34. https://doi.org/10.1016/j.healthplace.2015.11.002

Ebenbichler, G. R., Oddsson, L. I. E., Kollmitzer, J., & Erim, Z. (2001). Sensory-motor control of the lower back: Implications for rehabilitation. *Medicine and Science in Sports and Exercise*, *33*(11), 1889–1898. https://doi.org/10.1097/00005768-200111000-00014

Gabin, B., Camerino, O., Anguera, M. T., & Castañer, M. (2012). Lince: Multiplatform Sport Analysis Software. *Procedia - Social and Behavioral Sciences*, *46*, 4692–4694. https://doi.org/10.1016/j.sbspro.2012.06.320

Gorospe, G., & Anguera, M. T. (2000). Retrospectivity in polar coordinates analysis: application to tennis. *Psicothema*, *12*(SUPPL. 2), 279–282.

Gutiérrez-Santiago, A., Prieto, I., Camerino, O., & Anguera, M. T. (2011). The temporal structure of judo bouts in visually impaired men and women. *Journal of Sports Sciences*, *29*(13), 1443–1451. https://doi.org/10.1080/02640414.2011.603156

Harriss, D. J., & Atkinson, G. (2015). Ethical Standards in Sport and Exercise Science Research: 2016 Update. *International Journal of Sports Medicine*, *36*, 1121–1124. https://doi.org/10.1055/s-0035-1565186

Hernández-Mendo, A., López-López, J. A., Castellano, J., Morales-Sánchez, V., & Pastrana, J. L. (2012). HOISAN 1.2: Program for Use in Methodology Observacional. *Cuadernos de Psicología Del Deporte*, *12*(1), 55–78. https://doi.org/10.4321/S1578-84232012000100006

Imagama, S., Hasegawa, Y., Wakao, N., Hirano, K., Muramoto, A., & Ishiguro, N. (2014). Impact of spinal alignment and back muscle strength on shoulder range of motion in middle-aged and elderly people in a prospective cohort study. *European Spine Journal*

2014 23:7, *23*(7), 1414–1419. https://doi.org/10.1007/S00586-014-3251-9

Kingston, G. A., Williams, G., Gray, M. A., & Judd, J. (2014). Does a DVD improve compliance with home exercise programs for people who have sustained a traumatic hand injury? Results of a feasibility study. *Disability and Rehabilitation: Assistive Technology*, *9*(3), 188–194. https://doi.org/10.3109/17483107.2013.806600

Kuzala, E. A., & Vargo, M. C. (1992). The Relationship Between Elbow Position and Grip Strength. *The American Journal of Occupational Therapy*, *46*(6), 509–512. https://doi.org/10.5014/AJOT.46.6.509

Lee, J. L. C., Lo, T. L. T., & Ho, R. T. H. (2018). Understanding outdoor gyms in public open spaces: A systematic review and integrative synthesis of qualitative and quantitative evidence. *International Journal of Environmental Research and Public Health*, *15*(4). https://doi.org/10.3390/ijerph15040590

Lestan, K. A., Eržen, I., & Golobič, M. (2014). The role of open space in urban neighbourhoods for health-related lifestyle. *International Journal of Environmental Research and Public Health*, *11*(6), 6547–6570. https://doi.org/10.3390/ijerph110606547

Magnusson, M. S., Burgoon, J. K., & Casarrubea, M. (2016). *Discovering Hidden Temporal Patterns in Behavior and Interaction*. Springer-Verlag.

McGill, S. M., Cannon, J., & Andersen, J. T. (2014). Analysis of pushing exercises: Muscle activity and spine load while contrasting techniques on stable surfaces with a labile suspension strap training system. *Journal of Strength and Conditioning Research*, *28*(1), 105–116. https://doi.org/10.1519/JSC.0B013E3182A99459

Miller, J. S., Litva, A., & Gabbay, M. (2009). Motivating patients with shoulder and back pain to self-care: can a videotape of exercise support physiotherapy? *Physiotherapy*, *95*(1), 29–35. https://doi.org/10.1016/j.physio.2007.07.009

Padmasekara, G. (2014). Fitness apps, a Valid Alternative to the Gym: a pilot study. *Journal of Mobile Technology in Medicine*, *3*(1), 37–45. https://doi.org/10.7309/jmtm.3.1.6

Panjabi, M. M. (1992). The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of Spinal Disorders*, *5*(4), 383–389; discussion 397.

Reo, J. A., & Mercer, V. S. (2004). Effects of live, videotaped, or written instruction on learning an upper-extremity exercise program. *Physical Therapy*, *84*(7), 622–633.

Sackett, G. P. (1980). Lag Sequential Analysis as a data reduction technique in social interaction research. In D. B. Sawin, R. C. Hawkins, L. O. Walker, & J. H. Penticuff (Eds.), *Exceptional infant. Psychosocial risks in infant-environment transactions* (pp. 300–340). Brunner/Mazel.

Sallis, J. F., Owen, N., & Fisher, E. B. (2008). Ecological Models of Health Behavior. In K. Glanz, B.K. Rimer, & K. Viswanath (Eds.), *Health Behavior and: Health Education: Theory, Research, and Practice* (4th ed., pp. 465–485). Jossey-Bass.

Søgaard, K., Christensen, H., Jensen, B. R., Finsen, L., & Sjøgaard, G. (1996). Motor control and kinetics during low level concentric and eccentric contractions in man. *Electroencephalography and Clinical Neurophysiology - Electromyography and Motor Control*, *101*(5), 453–460. https://doi.org/10.1016/0924-980X(96)95629-5

Spanish National Institute of Statistics. (2017). *Encuesta sobre equipamiento y uso de tecnologías de información y comunicación en los hogares 2017 (TIC-H'17)*. http://www.ine.es/metodologia/t25/t25p450_hog_cues_02.pdf

Tarragó, R., Iglesias, X., Lapresa, D., Anguera, M. T., Ruiz-Sanchis, L., & Arana, J. (2017). Analysis of diachronic relationships in successful and unsuccessful behaviors by world fencing champions using three complementary techniques. *Anales de Psicología*, *33*(3), 471–485. https://doi.org/10.6018/analesps.33.3.271041

Van Hecke, L., Ghekiere, A., Van Cauwenberg, J., Veitch, J., De Bourdeaudhuij, I., Van Dyck, D., Clarys, P., Van De Weghe, N., & Deforche, B. (2018). Park characteristics preferred for adolescent park visitation and physical activity: A choice-based conjoint analysis using manipulated photographs. *Landscape and Urban Planning*, *178*(May), 144–155. https://doi.org/10.1016/j.landurbplan.2018.05.017

Weeks, D. L., Brubaker, J., Byrt, J., Davis, M., Hamann, L., & Reagan, J. (2002). Videotape instruction versus illustrations for influencing quality of performance, motivation, and confidence to perform simple and complex exercises in healthy subjects. *Physiotherapy Theory and Practice*, *18*(2), 65–73. https://doi.org/10.1080/09593980290058454

World Health Organisation. (2020). WHO guidelines on physical activity and sedentary behaviour, Web Annex, Evidence Profiles. In *World Health Organization*.

World Health Organization. (2010). Global recommendations on physical activity for health. In *World Health Organization*. World Health Organization. https://doi.org/10.1080/11026480410034349

TABLES

Table 1. Observational Instrument I.O.UPPERLIMB_FLEX-EXT

CRITERION	CODE	CATEGORY & DESCRIPTION
Shoulder	ISExt	Incomplete shoulder extension. The extension of the shoulder in the initial and final positions is less than 40º.
	ISFlex	Incomplete shoulder flexion. The shoulder flexion in position 2 is less than 30º.
	USFlex	Upper shoulder flex. The shoulder flexion in position 2 is greater than 40º.
Elbow	IEFlex	Incomplete elbow flexion. The elbow flexion in the initial and final positions is less than 125º.
	UEFlex	Upper elbow flexion. The elbow flexion in the initial and final positions is greater than 135º.
	IEExt	Incomplete elbow extension. The elbow extension in position 2 is greater than 40º.
	FEExt	Full elbow extension. The extension reaches 0 ° and can cause damage to the joint.
Wrist	WFExt	Wrist flexor-extension. A modification of the intermediate position occurs, making a flexor-extension during the movement.
	WAAbd	Wrist abduction-adduction. An abduction-adduction occurs during movement.
Hand	GH	Grip height. The grip on the handle is too high or too low, not allowing an alignment with the vertical part of the upper limb.
Cervical Spine	CFlex	Cervical flexion. A cervical flexion occurs during movement, modifying the neutral position
	CExt	Cervical extension. A cervical hyperextension occurs during movement.
Dorsal Spine	DFlex	Dorsal flexion. A hyperkyphosis occurs causing an increase in the convexity of the dorsal spine.
Lumbar Spine	LFlex	Lumbar flexion. The neutral position is modified, modifying the physiological curve through a lumbar flexion.
	LExt	Lumbar extension. The neutral position is modified, causing a lumbar swayback.
Ankle	ADFlex	Dorsal flexion. The support is not made with the middle part of the sole of the foot, causing the back of the foot to go towards the anterior side of the leg.
	APFlex	Plantar flexion. The support is not made with the middle part of the sole of the foot, causing the back of the foot to move away from the front of the leg.
Foot	SOTG	Support on the ground. The foot support is performed on the floor during movement instead of on the appliance bar.
Execution Speed	ExS	Execution Speed. The execution speed is too fast, making body control difficult.
Isometric Phase	NOIP	Omission. In the execution of the exercise, the isometric phase is not differentiated as a transition movement between the concentric and eccentric phases, making it excessively fast.
Starting Position	IncSP	Incorrect. The starting position is incorrect. Does not allow a flexion-extension of the upper extremities.

Table 2. Mean Values and Differences between Groups of Errors

		n	Mean±SD	95% CI		DG ANOVA		NT		HT	
				Low	Sup	Group	Sig	Z	Sig	LS	Sig
Upper Extremities	Video	18	2.27±1.96	1.30	3.25	Panel	.000[a]				
						Image	.000[a]				
	Panel	18	6.55±2.93	5.09	8.01	Video	.000[a]				
						Image	1[a]				
	Image	18	6.16±2.61	4.86	7.46	Video	.000[a]				
						Panel	1[a]				
	Total	54	5±3.16					.912	.377	1.396	.257
Lower Extremities	Video	18	.27±.66	-.05	.610	Panel	.000[b]				
						Image	.034[b]				
	Panel	18	1.72±1.17	1.13	2.30	Video	.000[b]				
						Image	.366[b]				
	Image	18	1.16±1.24	.54	1.78	Video	.034[b]				
						Panel	.366[b]				
	Total	54	1.05±1.20					2.412	.000	8.428	.173
Raquis	Video	18	1.11±1.32	.45	1.76	Panel	.004[a]				
						Image	.004[a]				
	Panel	18	3.55±2.47	2.32	4.78	Video	.004[a]				
						Image	1[a]				
	Image	18	3.55±2.43	2.34	4.76	Video	.004[a]				
						Panel	1[a]				
	Total	54	2.74±2.40					.971	.303	2.065	.137
Speed	Video	18	.27±.46	.04	.50	Panel	.000[b]				
						Image	.000[b]				
	Panel	18	.88±.32	.72	1.04	Video	.000[b]				
						Image	.348[b]				
	Image	18	1.11±.58	.82	1.40	Video	.000[b]				
						Panel	.348[b]				
	Total	54	.75±.58					2.542	.000	2.591	.085
Initial Position	Video	18	.00±.00	.00	.00	Panel	.000[b]				
						Image					
	Panel	18	.77±.42	.56	.99	Video	.000[b]				
						Image	.000[b]				
	Image	18	.00±.00	.00	.00	Video					
						Panel	.000[b]				
	Total	54	.25±.44					3.394	.000	38.08	.371
Final Errors Total	Video	18	3.94±2.89	2.50	5.38	Panel	.000[a]				
						Image	.001[a]				
	Panel	18	19±9.70	14.17	23.82	Video	.000[a]				
						Image	.004[a]				
	Image	18	12±3.80	10.10	13.89	Video	.001[a]				
						Panel	.004[a]				
	Total	54	9.81±5.63					.598	.867	.907	.410

SD = Standard Deviation; CI = Confidence Interval; DG = Difference between groups; NT = Normality Test; HT = Homoscedasticity Test; Low = Lower; Sup = Superior; Sig = Significance; Z = Z by Kolmogorov-Smirnov; LS = Levene Statistic; [a] Bonferroni; [b] Games-Howell

Table 3. Frequency, Percentage and T-Patterns of Errors in the Different Groups

FREQUENCY AND PERCENTAGE OF ERRORS							
		Video		**Image**		**Panel**	
Type	**Error**	**Fr.**	**%**	**Fr.**	**%**	**Fr.**	**%**
Upper Extremities Error	*ISExt*	19	52.78	17	47.22	5	62.5
	ISFlex	0	0	1	5.56	0	0
	USFlex	9	50	15	83.33	4	100
	IEFlex	0	0	5	13.89	0	0
	UEFlex	14	38.89	15	41.67	5	62.5
	IEExt	0	0	1	5.56	0	0
	FEExt	9	50	15	83.33	4	100
	WFExt	6	11.11	15	27.78	4	33.33
	WAAbd	7	12.96	15	27.78	5	41.7
	GH	8	44.44	13	72.22	2	50
Error Raquis	*CFlex*	8	14.81	22	40.74	0	0
	CExt	0	0	2	3.70	1	8.3
	DFlex	8	14.81	30	55.56	5	41.7
	LFlex	2	3.70	8	14.81	8	66.7
	LExt	3	5.56	2	3.70	0	0
Lower Extremities Error	*ADFlex*	2	3.70	13	24.07	1	8.3
	APFlex	0	0	7	12.96	5	41.7
	SOTG	0	0	1	5.56	4	100
Speed	*ExS*	0	0	4	22.22	0	0
	NOIP	6	33.33	16	88.89	4	100
Initial Position	*IncSP*	0	0	0	0	14	77.78

T-PATTERNS OF ERROR SEQUENCES			
Group	**T-Pattern**	**O**	**I**
Video	(WAAbd (ISExt UEFlex))	5	1
	(ISExt UEFlex)	12	2
	(USFlex FEExt)	9	3
Images	(ISExt UEFlex)	14	4
	(USFlex FEExt)	15	5
	(GH(USFlex FEExt))	12	6
	((WFExt ISExt)((UEFlex(CFlex DFlex))ADFlex))	4	7
	((WFExt(ISExt UEFlex))DFlex)	8	8
	(CFlex DFlex)	18	9
	(UEFlex(CFlex DFlex))	7	10
	(ISExt(UEFlex(CFlex DFlex)))	6	11
	((CFlex DFlex)(LFlex NOIP))	4	12
	(DFlex ADFlex)	11	13
	(WFExt DFlex)	13	14
	((WFExt ISExt)DFlex)	9	15
	(GH((WFExt ISExt)DFlex))	4	16
	((GH ISExt)UEFlex)	6	17
	(((GH ISExt)UEFlex)(USFlex FEExt))	5	18
	((GH WAAbd)(USFlex FEExt))	6	19
	(WAAbd IEFlex)	4	20
	(USFlex(FEExt LFlex))	5	21
	(USFlex(FEExt NOIP))	13	22
Panel	(ISExt UEFlex)	4	23
	(WAAbd(ISExt UEFlex))	4	24
	((SOTG(USFlex FEExt))(LFlex(APFlex NOIP)))	4	25

Fr. = Frequency; O = Occurrence; I = Identifier

FIGURES

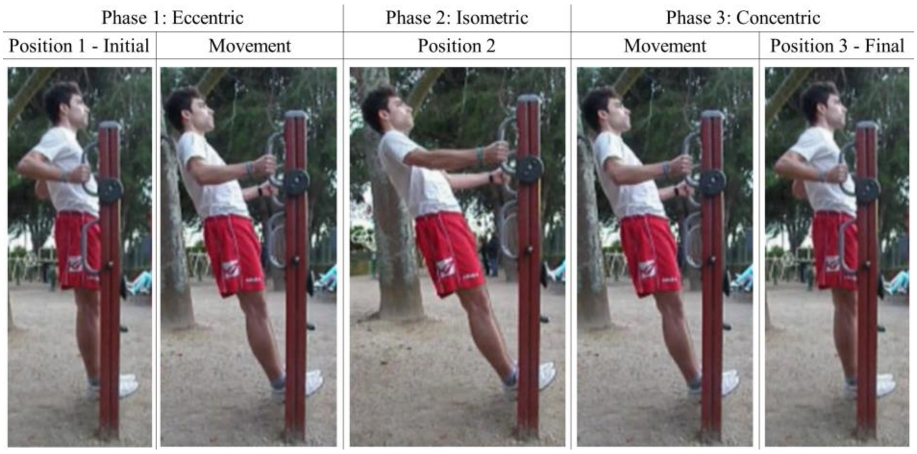

Figure 1. Movement Execution Model

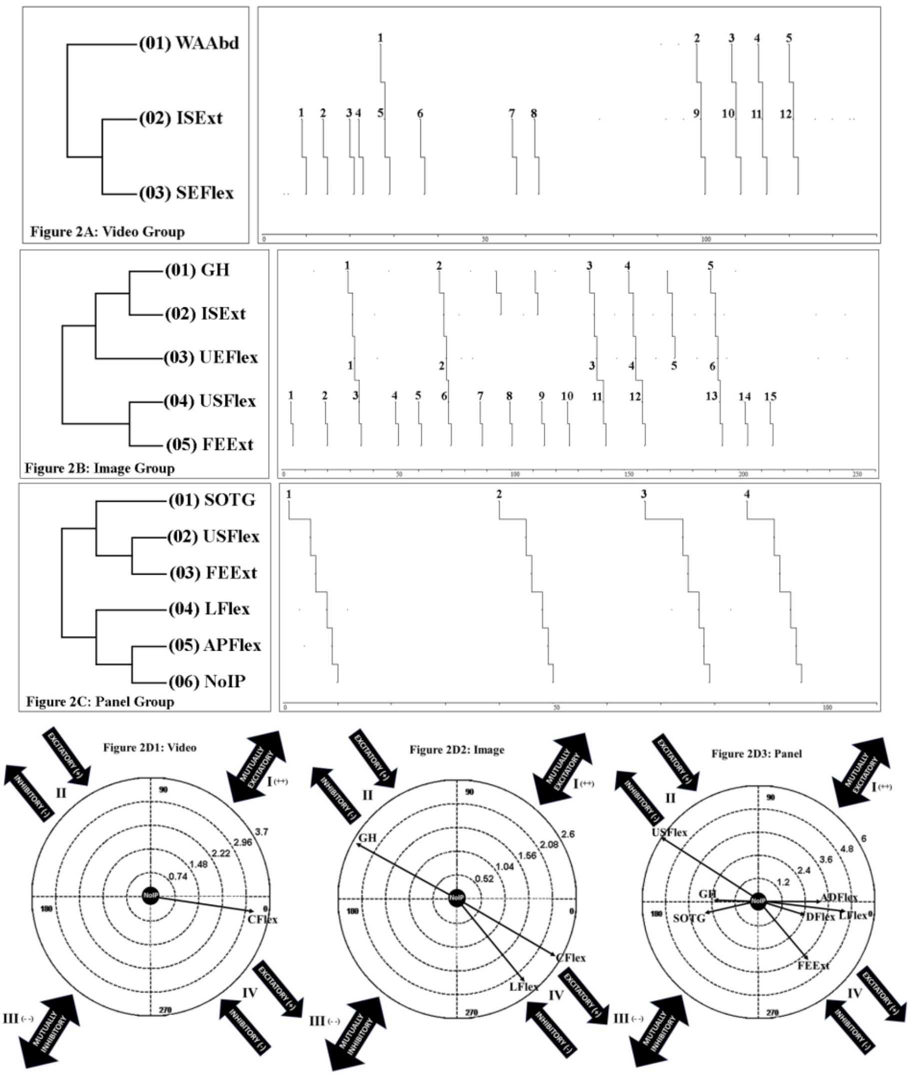

Figure 2. T-Patterns and Polar Coordinates of the Different Participant Groups.