Artículo de Revisión. DOI: https://doi.org/10.23754/telethusa.171901.2024

Monitoring Flamenco Dance Movement with Accelerometers: Methodological and Practical Commendations

Monitorización de Movimientos del Baile Flamenco con Acelerómetros: Recomendaciones Metodológicas y Prácticas

Ningyi Zhang (1)
Sebastián Gómez-Lozano, PhD (1)
Ross Armstrong, PhD (2)
Hui Liu, PhD (3)
Olaia Abadía García de Vicuña, PhD (4)
Alfonso Vargas-Macías, PhD (4)
(1) Performing Arts Research Group, Faculty of Sport, San Antonio Catholic University. Murcia, Spain.
(2) Rehabilitation and Healthy Lives Research Group, Institute of Health, University of Cumbria. Carlisle, United Kingdom.
(3) Biomechanics Laboratory, Beijing Sport University. Beijing, China.
(4) Telethusa Centre for Flamenco Research. Cádiz, Spain
Corresponding Author: nzhang@alu.ucam.edu

Recibido: 14 sep 2023 / Revisión editorial: 15 sep 2023 / Revisión por pares: 26 sep 2023 / Aceptado: 27 sep 2023 / Publicado online: 28 sep 2023

Abstract

Accelerometers are tools specifically engineered for quantifying differences in force or acceleration over time, providing data regarding the magnitudes and frequency of movement. It could be utilized in the flamenco dance study field for monitoring the movement to reduce the risks of injuries or pain, as well as to give recommendations for making a reasonable and scientific training plan for dancers to improve their technique. The aim of this study is to introduce how to monitor flamenco dance movement with accelerometers, and suggestions for future studies. This study makes a detailed introduction from the following aspects: accelerometer selection, monitor use protocols, and data process and analysis.

Key words

External load, dancer, biomechanics, acceleration, vibration.

Resumen

Los acelerómetros son herramientas diseñadas para cuantificar las variaciones en las fuerzas o aceleraciones en un período de tiempo, proporcionando datos sobre las magnitudes y frecuencia del movimiento. Pueden ser utilizados en el campo de estudio del baile flamenco para monitorizar el movimiento y reducir las dolencias y riesgos de lesiones, además de ofrecer recomendaciones para elaborar un plan de entrenamiento eficiente y con base científica para mejorar la técnica de los bailarines. El objetivo de este estudio es establecer unas pautas básicas sobre cómo monitorizar el movimiento del baile flamenco utilizando acelerómetros, y ofrecer sugerencias para futuras investigaciones. Este estudio profundiza en los siguientes aspectos: selección de acelerómetros, protocolos de uso del monitor y procesamiento, así como del análisis de los datos obtenidos.

Palabras clave

Cargas externas, bailaor, biomecánica, aceleración, vibración.

Introduction

Flamenco dance has been listed as an Intangible Heritage of Humanity in become a cultural feature of Spain, It is "a dance of passion, courtship, expressing a wide range of situations ranging from sadness to joy." [1]. It has gained worldwide prominence and attraction, captivating a growing community of enthusiasts in many countries. [2-5]. Flamenco dance is distinguished by its powerful emotional expression and distinctive footwork techniques, characterized by the striking of the floor to create a resounding and rhythmic sound. This sets it apart from other dance styles [2]. The rhythm and emotional expression are two of the most important elements for performing flamenco, which is indispensable for the precise execution of this dance form [6]. Mastering flamenco necessitates the development of motor skills that involve precise techniques and the coordination of various body parts like the feet, torso, arms among others [2].

Accelerometers are tools specifically engineered for quantifying differences in force or acceleration over time, providing data regarding the magnitudes and frequency of movement. When utilized for monitoring physical activity, these devices have the capability to detect movement in three planes of movement (medial-lateral, anterior-posterior and vertical) and to evaluate the intensity and overall amount of movement over a given time period [7]. It has already been used in sports or physical activity monitoring, as well as dance fields, to explore the physiological characterization of dance and physical activity levels during dancing [8-11].

Flamenco dance is a combination of physical movement and aesthetics that also requires a high level of physical demand, the physical effort demanded in performing flamenco is similar to that of elite sports [12-14]. Meanwhile, achieving a high level of skill and proficiency in dance also necessitates training and rehearsal, which may elevate the risk of potential injuries [15-17]. The injuries and pains have been already reported in flamenco dancers, which affect dancers not only their professional careers but also may have a negative effect on their daily lives [18-20]. On the other hand, to improve the skill and technique of dance, more theoretical studies also are necessary for the future. The instruments utilized are good for researchers to better understand how to study this field. Therefore, we would like to further emphasize the importance of using accelerometers and link it to the need for a more in-depth and comprehensive study of the technique. The aim of this study is to establish a specific proposal for monitoring flamenco dance movement with accelerometers, including the selection and validation of accelerometers, usage protocols, and data processing and analysis.

Accelerometers Selection

Generally, the choice of accelerometers largely depends on the specific research objectives with consideration of factors such as product reliability, access to technical support, feasibility, and cost [21]. Besides possessing adequate data processing and storage capabilities to track movement over extended periods is critical, we also have to consider if it is portable and compact for practical use in settings since in a flamenco dance test, accelerometers need to be posted on participants' body steady during performing dance for a period. We need to make sure the accelerometers do not drop during the dancers' performance and do not interfere with their dance moves during the test.

Out of the commercially accessible accelerometer brands, ActiGraph (Pensacola, FL, USA) stands out as the most commonly employed choice among researchers [22]. There are some examples about dance research. ActiGraph Triaxial accelerometers (GT3X+ 2.5, Actigraph LLC, Pensacola, USA) was used for describing the physical activity parameters of Latin dance [23]. Actigraph GT33 accelerometers were used in Kelli's research group, to record the physical activity, the intensity and time length of teenagers in different dance style classes of youth, including flamenco dance class. It was also widely used in other dance styles studies [24]. Additionally, Global Positioning Systems (GPS) with triaxial accelerometry [25,26], and triaxial accelerometer Kionix KX94 (Kionix, Ithaca, New York, USA) [9] were also utilized in other physical activity studies before.

About flamenco dance test, in 1998, Bejjani research group used two light-weight (2 g) skin-mounted unidirectional accelerometers (PCB 303; Power Supply 408), to record vibrations of hip and knee for ten flamenco dancers, indicated that vibrations generated by flamenco dancing may be linked to urogenital

Rev Cent Investig Flamenco Telethusa
2024 • 17(19) • pp.8-12

disorders, as well as back and neck pain, and the hip joint appears to absorb the majority of these impacts [8]. Voloshin et al, in 1989 recorded the amplitude of dynamic loading recorded on tuberosity, antero-superior iliac spine with two light-weight (2 g) skin-mounted unidirectional accelerometers as well, and revealed that utilizing insoles appears to decrease the amplitude of dynamic loading observed on the dancer's tibial tuberosity depending on the specific dance and performer [27]. Otherwise, in 2022, Zhang research group used Trigno Avanti™ sensors (Trigno Wireless EMG System, Delsys, Natick, MA, USA), which is a Triaxial Accelerometer having a built-in nine-degrees-of-freedom inertial measurement unit and can relay acceleration, rotation and earth magnetic field information, to record the flamenco Zap-3 footwork's external load responses. It described the external load at the dominant ankle, the 7th cervical vertebrae and the 5th lumbar, and the effect of speed, axis and the dancers' proficiency level on external load and their interaction [28]. The same research group also used the triaxial accelerometer to record the external load and analysis the correlation with ankle range of motion, and it pointed out that dorsiflexion affected the dominant ankle load in the anteroposterior axis for both professional and amateur dancers, as well as the cervical vertebrae load, which only affected amateurs. Plantarflexion only influenced the vertical axis load in professional dancers [29].

We recommend future studies use triaxial accelerometers to monitor flamenco technique tests. Existed research reported that triaxial accelerometers outperforms uniaxial accelerometry in capturing accelerations of sports consisting of smooth, horizontal or complex body movements [30]. Also, the effectiveness of triaxial accelerometers in dance detection has been proved. Nagy investigated within-day and between-day loading responses to ballet choreography and reported the effectiveness of triaxial accelerometers in dance monitoring [25]. In a study about flamenco dance external load, researchers identified significant effects of speed on external load [28]. To some extent, it means the accelerometer is sensitive enough to recognize the variation in the speed of flamenco footwork. Additionally, it also is better to use similar instruments as research in most recent years for comparing and discussing the results, since the difference between these devices makes it difficult to compare data between studies [31].

Monitor Use Protocols

Accelerometers can be fixed in many parts of the body. For example, ankles, wrists, torso, etc. The trunk position (hip or lower back) has become the most common position for monitors in general to monitor physical habitual, intensity [21]. For instance, the intensity of dance classes of different dance styles was studied too, including flamenco dance, where participants wore accelerometers in the position of waist [24]. Further, it has been indicated that when accelerometers are used for activity classification, the knee is the preferred sensor position for high-level activities. For transitional activities involving leg motion and posture changes, both chest and knee sensors are suitable choices [32]. However, the location of the accelerometer depends on the interest to be studied, for example, the accelerometer can also be placed in different body positions when the study aims to record data on a specific body position. For example in flamenco dance, the 7th cervical vertebrae, the 5th lumbar vertebrae, and superior to the lateral malleolus of the ankle were selected for quantifying the external load of the flamenco Zap-3 footwork while comparing the difference in those three body positions [29]. The accelerometers were also strapped onto the tibial tuberosity and the anterior superior iliac spine of flamenco dancers before for account acceleration amplitude, peak accelerations [8,27].

In flamenco dance experiments, the duration of wearing the accelerometer can be determined according to the needs of the interest. If studying a specific dance movement, it could be counted the time of the entire sequence of movements (usually more than 10 seconds), or the units of seconds or minutes based on the time it takes to complete the movement. If it is to estimate habitual, intensity of dancers, the time is determined according to the need, such as a dance class, a rehearsal, or a choreography. Similarly, the location of the experiment is also selected according to the needs of the experiment. The accelerometer is small and portable, the experiment can be conducted in the dance classroom, rehearsal hall or stage. The principle is to be as close as possible to the dancers' usual training, performance and class conditions, so as to ensure the authenticity and validity of the data.

Data analysis

Frequency and amplitude recorded by accelerometers have been used to quantify results in research. Bejjani [8] and Voloshin [27] used accelerometer data to analyze the vibrations with peak frequency ranges and amplitudes of acceleration. Otherwise, MeterPlus version 4.3 could be used to summarize minutes of sedentary, light, moderate, vigorous, and MVPA (moderate + vigorous) during physical activities. The research studied physical activity in youth dance using an accelerometer. Seven different dance classes (flamenco is one of them) were investigated. Outcomes as classes' total time (minutes) and per cent of class time (minutes divided by class length) spent in each intensity level were calculated.

The PlayerLoad (PL) concept allows for the quantification of a vector-modified algorithm introduced by the tech company Catapult Sports, which utilizes a micro-electrical mechanical system. PL is calculated as the square root of the sum of the squared rates of acceleration change along each of the three vectors (medial-lateral, anterior-posterior, and vertical), divided by 100. The micro-electrical mechanical system (MEMS) device includes a triaxial piezoelectric linear accelerometer that samples movement data at a frequency of 150 Hz, allowing for the precise quantification of movement performance. Due to its low user dependence, PL has found application in numerous physical activity tests for characterizing external load [10, 33-35] and is related to sports training and competition. In the field of dance research, PL has also been widely used to quantify the external load or mechanical load and its correlation with injuries [11,36, 37]. Nagy's research delved into within-day and between-day loading responses to ballet choreography. The study found that PL is suitably sensitive for tracking progressive routines, and accelerometers prove effective for athlete monitoring and injury screening protocols [25]. In flamenco footwork research, Playerload was utilized as the form to calculate external load, and analyzed correlation with other factors such ankle active range of motion, and balance ability [28,29,38].

The way to describe the acceleration data depends on the problem you are studying. The case of the above studies may give thinking of choosing the appropriate definition to describe the data. However, it does not mean they included all possibilities, the outcomes could also be other concepts with analysis acceleration. Standardizing the data with other research will facilitate comparison.

Conclusions

This study explained how to monitor flamenco dance movement with accelerometers by making a detailed introduction from aspects of accelerometer selection, monitor use protocols, and data process and analysis. Triaxial accelerometers were recommended to be used to monitor flamenco technique tests no matter what brand it is, which may better than uniaxial accelerometry for dance movement. The use of accelerometers in dance performance is often used to monitor physical conditions over a period of time, which can be days or seconds, depending on the problem to be studied. Accelerometers can be used in different settings, such as a classroom, rehearsal hall, or stage, and can also be placed in different locations on the body to obtain data. Existing studies of flamenco dance include the analysis of a dance technique movement by placing accelerometers at different locations to calculate external loads at different locations, or to describe vibrations. Another type of study looks at physical activity over time, such as the intensity and duration of exercise during a class. At present, there are many problems that can be studied by using accelerometers in flamenco dance, such as the intensity of physical activity in different chapters of a choreographer, or the analysis of acceleration data and related factors of other variables to interpret the physiological characteristics of flamenco dance more fully. Those studies will be significantly meaningful to deeply know the flamenco movement, giving advice to improve the techniques, prevent injuries or plan the training efficiently.

Documentary References

1. United Nations Educational, Scientific, and Cultural Organization. 2010. Decision of the Intergovernmental Committee: 5.COM 6.39. [Website]. https://ich.unesco.org/en/decisions/5.COM/6.39. Consultada 01 sep 2023.
2. Cuellar-Moreno M. 2016. Flamenco dance. Characteristics, resources and reflections on its evolution. Cogent Arts & Humanities 3(1): 1260825.
3. De Santiago PP. 2018. Flamenco: de la marginalidad social a la referencia cultural pasando por la apropiación política. Revista de Investigación sobre Flamenco La Madrugá 15: 91-115.

Rev Cent Investig Flamenco Telethusa
2024 • 17(19) • pp.8-12

4. Diamond C. 2018. Being Carmen: Cutting Pathways towards Female Androgyny in Japan and India. New Theatre Quarterly 34(4): 307-325.
5, Ropero M. 1995. El término flamenco. Historia del Flamenco. Sevilla: Tartesos.
6. Santaella C. 2010. Ensino-aprendizagem da dança flamenca à luz da psicanálise. [Tesis doctoral]. Campinas: Universidade Estadual de Campinas. https://repositorio.unicamp.br/acervo/detalhe/779202. Consultada 01 sep 2023.
7. Cliff DP, Reilly JJ, Okely AD. 2009. Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0–5 years. Journal of science and medicine in sport 12(5): 557-567.
8. Bejjani F, Halpern N, Pio A, Dominguez R, Voloshin A, Frankel V. 1988. Musculoskeletal demands on flamenco dancers: A clinical and biomechanical study. Foot Ankle 8(5): 254-263.
9. Brogden CM, Armstrong R, Page R, Milner D, Norris D, Greig M. 2018. Use of triaxial accelerometry during the dance aerobic fitness test: Considerations for unit positioning and implications for injury risk and performance. J Danc Med Sci 22(3): 115-122.
10. Bowen C, Weaver K, Relph N, Greig M. 2019. The Efficacy of Lower-Limb Screening Tests in Predicting PlayerLoad Within a Professional Soccer Academy. J Sport Rehabil 28(8): 860-865.
11. Moulder S, Armstrong R, Greig M, Brogden C. 2021. Effect of Kinesiology tape on tri-axial accelerometry during the Dance Aerobic Fitness Test. J Danc Med Sci 25(3): 191-199.
12. Pedersen ME, Wilmerding M, Kuhn BT, Enciñias-Sandoval E. 2001. Energy requirements of the American professional flamenco dancer. Med Probl Perform Artist 16(2) :47-52.
13. Vargas-Macías A. 2009. El Baile Flamenco: Estudio Descriptivo, Biomecánico y Condición Física. Cádiz: Centro de Investigación Flamenco Telethusa.
14. Vargas-Macías A, Montesinos JLG, Vicente JM, Lozano SG. 2008. La necesidad de la preparación física en el baile flamenco. Rev Cent Investig Flamenco Telethusa 1(1): 4-6.
15. Angioi M, Metsios G, Koutedakis Y, Wyon MA. 2009. Fitness in contemporary dance: a systematic review. Int J Sports Med 30(7): 475-484.
16. Bronner S, Ojofeitimi S, Spriggs J. 2003. Occupational musculoskeletal disorders in dancers. Phys Ther 8(2): 57-68.
17. Motta-Valencia K. 2006. Dance-related injury. Phys Med Rehabil Clin N Am 17(3): 697-723.
18. Baena-Chicón I, Gómez-Lozano S, Abenza-Cano L, García O, Fernández-Falero MR, Vargas-Macías A. 2020. Las algias como factor predisponente de lesión en estudiantes de baile flamenco. Cultura, Ciencia y Deporte 15(44): 245-53.
19. Forczek W, Baena-Chicón I, Vargas-Macías A. 2016. Variación de la posición del centro de gravedad en una bailaora profesional durante el zapateado flamenco. Rev Cent Investig Telethusa 9(10): 30-6.
20. Pedersen M, Elizabeth, Wilmerding V. 1998. Injury profiles of student and professional flamenco dancers. J Dance Med Sci 2(3): 108-14.
21. Ward DS, Evenson KR, Vaughn A, Rodgers AB, Troiano RP. 2005. Accelerometer use in physical activity: best practices and research recommendations. Med Sci Sports Exerc 37(11Suppl): S582-S588.
22. Wijndaele K, Westgate K, Stephens SK, et al. 2015. Utilization and harmonization of adult accelerometry data. Med Sci Sports Exerc 47(10): 2129-2139.
23. Domene PA, Easton C. 2014. Combined triaxial accelerometry and heart rate telemetry for the physiological characterization of Latin dance in non-professional adults. J Danc Med Sci 18(1): 29-36.
24. Cain KL, Gavand KA, Conway TL, Peck E, Bracy NL, Bonilla E, Sallis JF. 2015. Physical activity in youth dance classes. Pediatrics 135(6): 1066-1073.
25. Nagy P, Brogden C, Orr G, Greig M. 2022. Within-and between-day loading response to ballet choreography. Research in Sports Medicine 30(6): 616-627.
26. Armstrong R, Brogden CM, Milner D, Norris D, Greig M. Functional movement screening as a predictor of mechanical loading and performance in dancers. Journal of Dance Medicine & Science. 2019;22(4):203-208.
27. Voloshin AS, Bejjani FJ, Halpern M, Frankel VH. 1989. Dynamic loading on flamenco dancers: a biomechanical study. Hum mov sci 8(5):503-513.
28. Zhang N, Gómez-Lozano S, Armstrong R, Liu H, Vargas-Macías A. 2022. External load of flamenco Zap-3 footwork test: use of PlayerLoad concept with triaxial accelerometry. Sensors 22(13):4847.
29. Zhang N, Gómez-Lozano S, Armstrong R, Liu H, Vargas-Macías A. 2023. Ankle Active Range of Motion as an Essential Factor of Footwork Technique in the Prevention of Overuse Injuries in Flamenco Dancers. Arch Med Deporte 40(2): 77-84.
30. Smith MP, Horsch A, Standl M, Heinrich J, Schulz H. 2018. Uni-and triaxial accelerometric signals agree during daily routine, but show differences between sports. Scientific reports 8(1): 15055.
31. Migueles JH, Cadenas-Sanchez C, Ekelund U, Delisle Nyström C, Mora-Gonzalez J, Löf M, Ortega FB. 2017. Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations. Sports medicine 47(9): 1821-1845.
32. Atallah L, Lo B, King R, Yang GZ. 2011. Sensor positioning for activity recognition using wearable accelerometers. IEEE transactions on biomedical circuits and systems 5(4): 320-329.
33. Bredt SdGT, Chagas MH, Peixoto GH, Menzel HJ, de Andrade AGP. 2020. Understanding player load: Meanings and limitations. J Hum Kinet 71: 5-9.
34. Scanlan AT, Fox JL, Milanovic Z, Stojanovic E, Stanton R, Dalbo VJ. 2021. Individualized and fixed thresholds to demarcate PlayerLoad intensity zones produce different outcomes. J Strength Cond Res 35(7): 2046-2052.
35. Bullock GS, Schmitt AC, Chasse P, Little BA, Diehl LH, Butler RJ. 2021. Differences in PlayerLoad and pitch type in collegiate baseball players. Sports Biomech 20(8): 938-946.
36. Armstrong R, Brogden CM, Greig M. 2019. The Star Excursion Balance Test as a predictor of mechanical loading and performance in dancers. Gazz Med Ital Arch Sci Med 178(3): 98-105.
37. Armstrong R, Brogden CM, Greig M. 2020. Joint Hypermobility as a Predictor of Mechanical Loading in Dancers. J Sport Rehabil 29(1): 12-22.
38. Zhang N, Gómez-Lozano S, Armstrong R, Liu H, Vargas-Macías A (in press). The Effect of Lower Limb Balance Ability and Bilateral Asymmetry on Flamenco Footwork. Cultura, ciencia y deporte.