Petra Zaletel[1*]
Goran Vučković[1]
Nic James[2]
Andrej Rebula[3]
Meta Zagorc[1]

A TIME-MOTION ANALYSIS OF BALLROOM DANCERS USING AN AUTOMATIC TRACKING SYSTEM

ANALIZA GIBANJA PLESALK IN PLESALCEV V STANDARDNIH PLESIH Z UPORABO SLEDILNEGA SISTEMA

ABSTRACT

The physical effort of athletes has been widely studied e.g. in soccer (Bangsbo, Krustrup and Mohr, 2006), but has not received much attention in dance. Consequently the physical demands of six ballroom (BR) dance couples (three adult International couples ("Adult") and three elite youth couples ("Youth")) were analysed when performing BR dances. The dances were recorded directly onto DVD using one camera located directly above the dance floor at a frequency of 25 frames per second. The recordings were analysed with the SAGIT tracking system to determine the trajectories, distance and speed of the dancers.

A comparison of the Adult and Youth couples' trajectories showed that the younger, less experienced dancers used the basic choreographic form through the circle while the Adult couples consistently used the inner space of the dance floor. The biggest differences between the two sets of dancers were found in the Waltz, Tango and Quickstep. The dynamics of movement (distance covered and speed) tended to decrease in line with the experience of the dancing couple involved. The Adult couples made longer and faster trips than the Youth couples for all dances except the Foxtrot. These performance differences seemed to relate to the softness in the complex movements which was apparent in the speed of the Adult dancers whereas the simpler movements of the Youth dancers did not allow this feature to be distinguished.

Keywords: dance, ballroom, trajectory, distance covered, speed of movement, SAGIT

[1]University of Ljubljana, Faculty of Sport, Slovenia
[2]Middlesex University, London Sport Institute, UK
[3]Independent researcher, Slovenia
****Corresponding author:***
Petra Zaletel, PhD
University of Ljubljana, Faculty of Sport, Gortanova 22,
SI-1000 Ljubljana, Slovenia
Tel.: +386 1 5207700, fax: +386 1 5207750
E-mail: petra.zaletel@fsp.uni-lj.si

POVZETEK

Številni avtorji so preučevali telesno obremenitev različnih športnikov, na primer v nogometu (Bangsbo, Krustrup and Mohr, 2006), vendar pa tovrstnih raziskav v plesu še ni bilo. Analizirali smo gibanje in obremenitev v petih standardnih plesih (BR) na šest plesnih parov, med katerimi so bili trije članski in trije mladinski pari. Plesne pare smo snemali na DVD, z uporabo kamere s frekvenco 25 posnetkov na sekundo, ki je bila nameščena navpično nad plesiščem. Posnetke smo analizirali s sledilnim sistemom SAGIT ter tako določili trajektorije, razdalje in hitrosti plesalk in plesalcev.

Primerjava trajektorij članskih in mladinskih parov kaže, da so mlajši in manj izkušeni pari uporabljali osnovne koreografske forme plesanja po krožnici, medtem ko so članski pari veliko bolj uporabljali tudi notranji del plesnega prostora. Najizrazitejše razlike med dvema skupinama plesnih parov so bile v počasnem valčku, tangu in hitrem fokstrotu. Dinamika gibanja (razdalja in hitrost) pa se je zmanjševala skladno s količino plesnih izkušenj. Članski pari so v primerjavi z mladinskimi pari prikazali daljša in hitrejša potovanja po prostoru v vseh plesih razen v počasnem fokstrotu. Razlike v nastopu članskih in mladinskih parov lahko najverjetneje povežemo z lahkotnostjo zapletenih gibanj pri članskih parih, medtem ko so gibanja mladinskih parov preprostejša.

Ključne besede: ples, standardni plesi, trajektorije, razdalja, hitrost gibanja, SAGIT

INTRODUCTION

Sport dancing has a long tradition in Slovenia with many great international successes having been achieved in sport dancing competitions. It is a sport which combines energy and information components with a particular emphasis on the aesthetics of movement (Zaletel, Tušak, Tušak, & Zagorc, 2005). Of course, dancers have to be physically well-prepared to achieve the status of a top dancer and to execute moves beautifully, achieve harmony in movement, precision, synchronisation with music etc. The ultimate aim is to achieve an artistic impression through aesthetic and physical preparation.

It is already known that successful movement performances in some sports with aesthetic components can be predicted by the motor abilities and morphological characteristics of the athletes involved (Kostić, 1997; Kostić & Dimova, 1997; Claessens et al., 1999; Mišigoj – Duraković et al., 2001; Kostić, Zagorc, & Uzunović, 2004; Uzunović & Kostić, 2005). Physique plays a significant role in the performance of elite artistic (Claessens & Lefevre, 1998) as well as elite rhythmic gymnasts (Alexander, 1991). Several authors have determined the positive influence of co-ordination (Miletić et al., 1998; Kioumourtzoglou et al., 1997) and flexibility (Hume et al., 1993) on performance efficiency in related movements that have aesthetic components. In addition to the aesthetic movement and morphological characteristics (Da Silva & Bonorino, 2008, Claessens, Nuyts, Lefevre, & Wellens, 1987), many other skills and characteristics are important for sport dancers (Brown, Martinez, & Pearsons, 2006; Zagorc, 2000). Studies show a high physiological load on sport dancers (Jaray & Wanner, 1984; Zagorc, Karpljuk, & Friedl, 1999; Zagorc & Kanduč, 2009).

Older adults who participate in dance have an increased motivation to pursue healthy, exercise-related behaviours and demonstrate improved balance and functional mobility (Federici, Bellagamba, & Rocchi, 2005; Eyigor, Karapolat, Durmaz, Ibisoglu, & Cakir, 2009). Jacobson, McKinley, Leroux and Rainville (2005) reported greater balance and complex gait task improvements in older people who participated in Argentine tango compared to a group that walked for their exercise. Finally, habitual participation in social dancing over several years is associated with superior balance, postural stability, gait function and leg reaction times compared to age-matched non-dancers (Verghese, 2006; Zhang, Ishikawa-Takata, Yamazaki, Morita, & Ohta, 2008).

Dance is an art that develops in both space and time (Da Silva & Bonorino, 2008), expressing emotions through physical movement (Dantas, 1999). It involves a sequence of gestures, steps and movements with musical rhythm that express affectionate states (Catarino, 2002). Zucolloto and Freire (2003) suggested that as a dance performance moves closer to perfection it becomes harder to distinguish the individual elements (effort, gravity, body, muscular strength, objects, sound) of the dance.

Time and space are two essential parameters of a dancer's expressiveness (Minvielle-Moncla, Audiffren, Macar, & Vallet, 2008), with the accuracy of the timing of the movement being a major asset in a choreographic production. An extremely important feature of dance is the ability to adapt the timing of the executed steps, movement structures and dance figures to the accompanying music and to a partner's motion.

Many studies have examined the physical effort of athletes; for example, in soccer (Bangsbo, Krustrup, & Mohr, 2006), basketball (Ben Abdelkrim, El phase, & El Ata, 2007), rugby (Deutch, Kearney, & Rehrer, 2007), handball (Šibila, Vuleta, & Pori, 2005), volleyball (Mauthner, Koch,

Tilp, & Bischof, 2007) and squash (Hughes, Franks, & Nagelkerke, 1989). Surprisingly, despite the popularity of dance, there is a very limited amount of literature investigating dancers' movements through the two-dimensional space as well as the range and speed of movement. Recently, Zaletel, Vučković, Rebula and Zagorc (2010) conducted a pilot study on dancers' movements in selected ballroom (BR) and Latin-American dances. They found that the paths of the female and male dancer in BR dances were almost identical, while in Latin-American dance this was not the case. Consequently, they concluded that there was no need to track BR dance partners separately. Hence this paper will qualitatively assess dance couples in all five BR dances (Waltz, Tango, Viennese Waltz, Slow Foxtrot and Quickstep) to determine whether differences in distance covered and speed of movement exist between elite adult and youth dancers.

METHODS

Participants

Six elite BR dance couples (each involving a male and female) who danced competitively and were training every day volunteered to participate in the study. Three were adult internationally ranked couples (age M=23.8; SD=2.2; Adult) and three were youth, also internationally ranked, couples (age M=15.0; SD=3.0; Youth) who had different choreographies. The current World Champions for youth and adult BR dancing were participants. The Youth couples, followed by the Adult couples, danced five BR dances (Waltz, Tango, Viennese Waltz, Slow Foxtrot and Quickstep) in succession with 30 second breaks in between.

Instruments

The dancers were recorded directly onto DVD with one camera (Ultrak KC CCD Colour CP 7501, Japan) at a frequency of 25 frames per second. The camera was secured to the ceiling of the hall to enable the recording of a rectangular projection of the whole dance area. This was made possible by using a wide-angle lens (Ultrak KL2814IS, Japan).

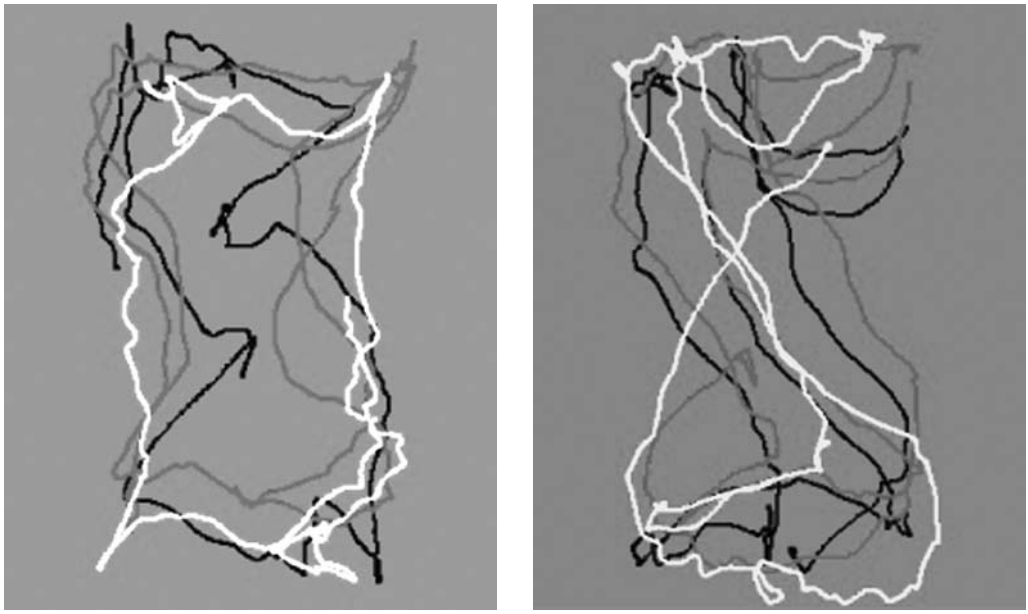
Procedure

The footage was later transferred to a PC and analysed with the SAGIT tracking system, a human tracking measurement system based on computer-vision technology (Perš, Bon, Kovačič, Šibila, & Dežman, 2002). This system has been successfully used on several occasions to study the physical effort of athletes in handball (Bon, 2001), basketball (Erčulj, Vučković, Perš, Perše, & Kristan, 2008), squash (Vučković, Perš, James, & Hughes, 2010) and tennis (Filipčič, 2008).

RESULTS

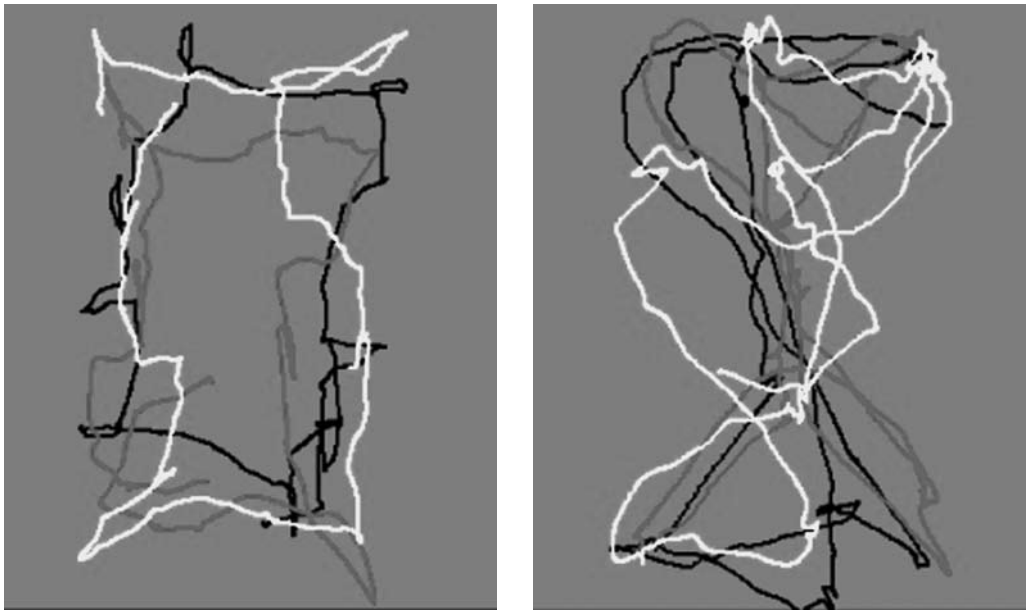
The trajectory of movement for the dance pairs in Waltz showed a wide movement in space, primarily in the circle. The path of the dance couple was focused on every corner of the dance floor where the couple did not delay too long, enabling the dancers to present different actions in the dance: stillness, restraint of movement, weight transfer, lift and fall, travelling through space once again. These trajectories showed that the Adult couples executed the changes in a diagonal, which is typical of BR choreography. Usually, in the middle of the diagonal there is

a dance figure, which is executed at a certain site in order to attract viewers and judges and to change the rhythm of movement.



Youth Adult

Figure 1: Trajectories of three Youth and three Adult dance couples in the Waltz



Youth Adult

Figure 2: Trajectories of three Youth and three Adult dance couples in the Tango

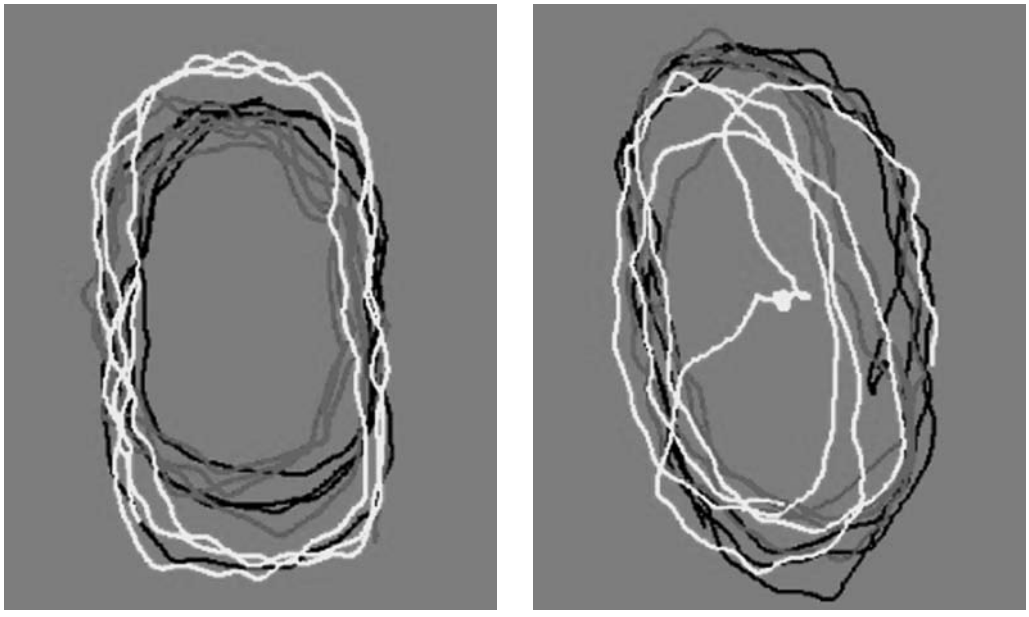
The trajectories of the Youth couples showed less movement in the interior of the dance floor and more on the outside of the circle. The exception in this case was the trajectory of the dancers shown in black (Figure 1) which indicated the choreographic features of more experienced dancers.

Tango is a specialty of BR dances and contains quite a few differences: the posture is firmer, there are no rises and descents like in other BR dances, the foot technique is more pronounced and complex. The trajectory of movement in Tango showed that Tango is typically characterised by a circular movement, but more rhythmically sharp, cut off. Figure 2 shows the sharp corners when changing directions, which are also characteristic of Tango.

A comparison of the Adult and Youth couples' trajectories showed that the younger and less experienced categories were still using the basic choreographic form through the circle, while the top dance couples were looking for a way inside the dance floor.

The Viennese Waltz is a quick rotating BR dance with a subtle rise and fall. A simple and elegant rotational movement characterises the Viennese Waltz. Trajectories in the Viennese Waltz (Figure 3) indicated fluid, smooth and easy movements around the circle in a dance direction. Besides right and left turns, which seem to be constantly exchanging in Viennese Waltz, "the blue couple" (Adult) included in their choreography the "fleckerl" step – a spot turn in which dance couples will dance in the middle of the dance floor and turn in one cycle by 360 degrees (in place).

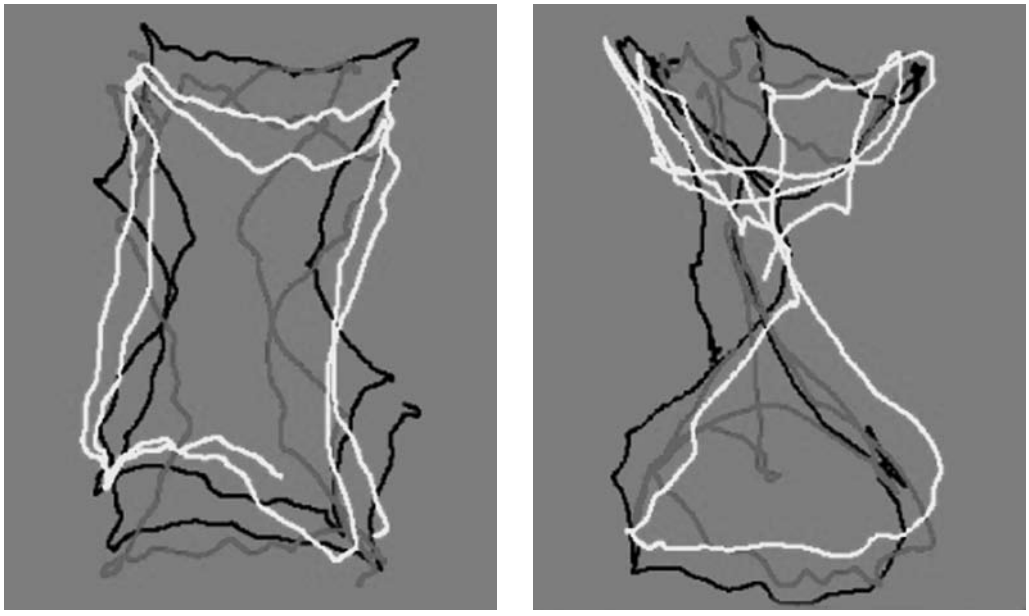
The Viennese Waltz contained the fewest differences in trajectories between the Adult and Youth couples. Its characteristics are rapid and continuous rotations, while the choreography is limited to right and left turns. More important than the choreographic complexity of this dance are the speed and performance of the movement, as well as the softness of the rises and falls.



Youth Adult

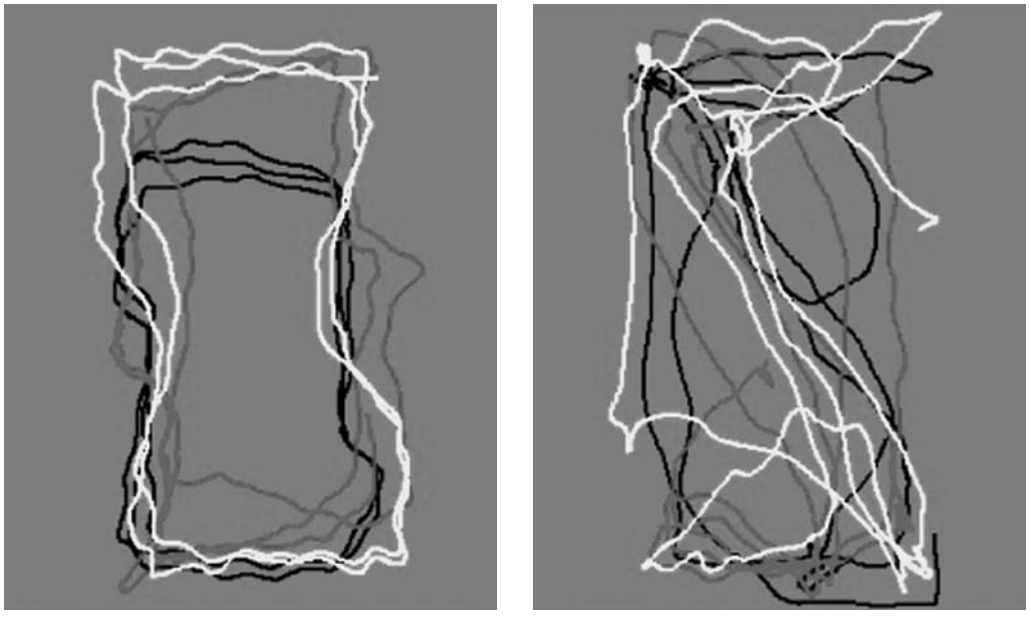
Figure 3: Trajectories of three Youth and three Adult dance couples in the Viennese Waltz

The motion trajectory of Youth couples in Foxtrot (Figure 4) and Quickstep (Figure 5) showed a wide movement around the space in the direction of the circle, which was not apparent with the Adult couples who were dancing on the outer edge of the circle and continuing in the centre of the dance floor.



Youth Adult

Figure 4: Trajectories of three Youth and three Adult dance couples in the Foxtrot



Youth Adult

Figure 5: Trajectories of three Youth and three Adult dance couples in the Quickstep

Table 1: Details of the path and speed of movement of Adult and Youth couples in all five BR dances

	YTH1	*YTH 2*	*YTH 3*	*AVERAGE YTH*	*ADU1*	*ADU 2*	*ADU 3*	*AVERAGE ADU*
Waltz speed (m/s)	0.87	1.13	0.85	0.95	1.12	1.2	1.15	1.16
Waltz path (m)	82	106	79	89	105	113	108	108.67
Tango speed (m/s)	0.82	0.84	0.8	0.82	1.18	1.07	1.11	1.12
Tango path (m)	76	78	75	76.33	115	104	109	109.33
Viennese Waltz speed (m/s)	1.55	1.78	1.54	1.62	1.96	1.91	1.79	1.89
Viennese Waltz path (m)	141	162	140	147.67	171	167	156	164.67
Foxtrot speed (m/s)	0.98	1.04	1.08	1.03	1.1	1.24	1.18	1.17
Foxtrot path (m)	85	90	94	89.67	97	109	104	103.33
Quickstep speed (m/s)	1.3	1.45	1.31	1.35	1.53	1.62	1.64	1.60
Quickstep path (m)	112	124	112	116	139	148	149	145.33

Legend: YTH - Youth dance couples, ADU - Adult dance couples

The results showed that the dynamics of movement (length of the path and speed) decreased in line with the experience of the dancing couple involved. The Adult couples made about 20-30m longer trips on average and on average were about 0.3 m/s faster, except in Foxtrot. This characteristic was confirmed by the present softness and speed in the BR dances, which is regarded as a key to success in dance choreography and technique.

DISCUSSION

BR dances have been developed in Europe, where the English created a distinctive natural and easy style. BR dances have a more subdued character and use a closed dance position. The dance partners are in constant contact with each other while dancing around a virtual circle around the room, in an anticlockwise direction. Movement in BR dances is current, still fast, emphatic periods in music (at the beginning of each cycle) are followed by extended and emphasised steps, which seems to involve the ability of dancers to correctly interpret the characteristics of the movement of a particular dance.

The movement and path of a BR dance couple has a meaning in the space – to create an image of softness, rhythm, travel, power, passion or game. By changing the speed of movement dancers try to create an illusion of lightness and aesthetic perfection for both the viewer as well as the judge.

A pilot study of the analysis of the load of dance couples in selected BR and Latin-American dances through the SAGIT tracking system (Zaletel, Vučković, Rebula, & Zagorc, 2010) discovered that both female and male dancers had almost identical trajectories of movement and their speed trends were also very similar. BR dancers danced in a closed position so the partners were travelling together on the same path and could be considered as a single object. Further, their speeds were the same as they must operate as one, move through the space easily, giving the impression of controlled movement. Technical requirements dictate holding the correct body positions in

various motor actions, which in BR dances include the proper foot technique, lifts, drops, swings, body rotations in all directions, performed to a rhythmic musical accompaniment.

The Waltz is one of the smoothest BR dances. It is a progressive dance marked by long, flowing movements, continuous turns, and rises and falls. The dance is so graceful and elegant that Waltz dancers appear to glide around the floor with almost no effort. The Foxtrot is very similar to the Waltz. Both are extremely smooth dances that travel along a line of dance anticlockwise around the floor. The rise and fall action of the Foxtrot comes from the long walking movements made by the dancers. The dance combines quick steps with slow steps, giving dancers more flexibility in movement and greater dancing pleasure.

The Foxtrot is a smooth dance in which dancers make long, flowing movements across the floor. The Quickstep is a quick version of the Foxtrot. It is a BR dance comprising extremely quick steps, syncopated feet rhythms, and runs of quick steps. The Quickstep is exciting to watch, but one of the most difficult of all the BR dances.

In Quickstep, the Adult dance couples strung a series of typical Quickstep figures together which showed the precise control of their foot technique. Their choreography included fast movements in complex structures. All are specific to the Quickstep, including sudden stops, sudden changes in direction, which were not apparent in the choreography of the Youth dancers.

Because of the speed of the dance there is a danger that couples might collide with each other so it is wise to choose space in the interior dance floor, like the Adult dancers did. This also gives a better view of the dance floor and prevents unpleasant situations. The Adult couples were looking for a way inside the dance floor and therefore they used more space to perform the complex dance figures and avoid the crowd on the outskirts of the dance circle. At competitions, there is more than one dance couple on the floor at the same time. Collisions of dance couples especially in the high speed Quickstep are therefore often inevitable.

Dance is multi-directional and involves the use and co-ordination of different muscle groups at varying times. Increased movement dynamics call for greater control and co-ordination of the torso muscles of dance partners, as shown in previous studies (Zaletel, Tušak, & Zagorc, 2006).

The dance executed by the Youth couples seemed more monotonous than with the Adult couples, not exploring the dance floor as a whole, which is less choreographically creative in terms of the space used and therefore lead to less distance being covered by the Youth dancers.

CONCLUSION

The excellence of BR dance couples is reflected in the fact they seem to be as one, as a whole, and move around the dance floor in accordance with the characteristics of each specific dance. In the last decade, BR dances have increased the complexity of their choreographies and the performance of individual elements. Each dancer has different contents and wants to communicate to viewers and judges, not least to their dance partner. The choreography combines the character of each dance with music; the dancer's expression only amplifies the story. However, top control of the body in various dance figures is the key element of the best dancers, which is certainly visual (according to dance judges) and also influenced by the speed of the movement.

The SAGIT tracking system showed the satisfactory path and speed of the dancers and yielded information about their work load during the dance. In the future, in addition to the SAGIT

tracking module we also plan to use the annotating module (Vučković, Dežman, & Perš, 2006) which will allow an analysis of individual dance elements and fine movements with the hands, head etc. Thus, it will be possible to determine not only the frequency of these elements occurring, but also their sequence. It would also be interesting to identify the dynamics of female and male dancers when implementing aesthetically perfect figures of each dance. Although some dance actions often occur on the spot, they still represent a significant portion of the final assessment of the dancer's performance.

REFERENCES

Abdelkrim, B. N., El Fazaa, S., & El Ati, J. (2007). Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. British Journal of Sports Medicine, 41, 69-75.

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. Journal of Sports Sciences, 24(7), 665-674.

Bon, M. (2001). Kvantificirano vrednotenje obremenitev in spremljanje frekvence srca igralcev rokometa med tekmo [Quantified evaluation of the effort and monitoring the heart rate of male players during a team handball match]. Doctoral dissertation. Ljubljana: Faculty of Sport.

Brown, S., Martinez, M.J., & Pearsons, L.M. (2006). The neural basis of human dance. Life Sciences & Medicine, Cerebral Cortex, 16(8), 1157-67.

Catarino, M. (2002). Historia da danca, http://gape.ist.utl.pt, accessed 11 October 2010.

Claessens, A. L., Lefevre, J., Beunen, G., & Malina, R. M. (1999). The contribution of anthropometric characteristics to performance scores in elite female gymnasts. Journal of Sports Medicine and Physical Fitness, 39(4), 355-360.

Claessens, A.L., Nuyts, M.M., Lefevre, J.A., & Wellen, R.I. (1987). Body structure, somatotype, maturation of adolescent and professional classical ballet dancers. Journal of Sports Medicine and Physical Fitness. 29, 157-62.

Da Silva, A.H., & Bonorino, K.C. (2008). BMI and flexibility in ballerinas of contemporary dance and classical ballet. Fitness Performance Journal, 7(1), 48-51.

Dantas, E.H.M. (1999). Flexibilidade: alongamento e flexionamento. 4th ed. Rio de Janeiro: Shape.

Erčulj, F., Vučković, G., Perš, J., Perše, M., & Kristan, M. (2008). Establishing basketball players' velocity and distance covered during a basketball match with the Sagit computer tracking system. Journal of Coimbra Network on Exercise Sciences, 4, 50-59.

Eyigor S., Karapolat H., Durmaz, B., Ibisoglu, U., & Cakir, S. (2009). A randomized controlled trial of Turkish folklore dance on the physical performance, balance, depression and quality of life in older women. Archives of Gerontology and Geriatrics, 48(1), 84-88.

Federici, A., Bellagamba, S., & Rocchi, M.B. (2005). Does dance based training improve balance in adult and young old subjects? A pilot randomized controlled trial. Aging Clinical and Experimental Research, 17(5), 385–389.

Filipčič, T. (2008). Igralne značilnosti gibalno oviranih v tenisu na vozičku in njihov vpliv na uspešnost igranja [Playing characteristics of the physically impaired and their influence on success in wheelchair tennis]. Doctoral dissertation. Ljubljana: Faculty of Sport.

Hughes, M., Franks, I.M., & Nagelkerke, P. (1989). A video-system for the quantitative motion analysis of athletes in competitive sport. Journal of Human Movement Studies, 17, 217-227.

Hume, P.A., Hopkins, W.G., Robinson, D.M., Robinson, S.M., & Hollings, S.C. (1993). Predictors of attainment in rhythmic sportive gymnastics. Journal of Sports Medicine and Physical Fitness, 33(4), 367- 377.

Jacobson, A. C., McKinley, P. A., Leroux, A., & Rainville, C. (2005). Argentine tango dancing as an effective means for improving cognition and complex task performance in at-risk elderly: a feasibility study. Program No. 757.7. 2005 Abstract Viewer/Itinerary Planner. Washington, DC: Society for Neuroscience.

Jaray, F., & Wanner, H. U. (1984). Heart rate and dance rhythm during dance tournament. Schweizerische Zeitschrift für Sportmedizin, 32(2), 44-48.

Kioumourtzoglou, E., Derri, V., Tzetzis, G., & Kourtessis, K. (1998). Predictors of success in female rhythmic gymnasts. *Journal of Human Movements Studies, 34*(1), 33-48.

Kostić, R. (1997). Uticaj dvonedeljnog treninga na motoričke sposobnosti plesačica [Influence of two weeks' training on the motor abilities of female dancers]. In R. Kostić (ed.), *Šesti međunarodni simpozijum "Fis komunikacije 1997" u fizičkom vaspitanju, sportu i rekreaciji [Sixth International Congress "Fis Communications '97" in Physical Education, Sports and Recreation]* (pp. 107-114). Niš: Filozofski fakultet, Univerzitet u Nišu, Institut fizičke kulture.

Kostić, R., & Dimova, K. (1997). Karakteristike morfoloških pokazatelja i frekvencije pokreta na uzorku plesača sportskog plesa [The Characteristics of Morphological Indicators and Motion Frequency in the Case of a Sample of Sport Dancers]. In Zbornik radova *"FIS komunikacije 1997"* (pp. 124-128). Niš: Filozofski fakultet, Serija fizička kultura.

Kostić, R., Zagorc, M., & Uzunović, S. (2004). Prediction of success in sports dancing based on morphological characteristics and functional capabilities. *Acta Universitatis Palackianae Olomucensis Gymnica, 34*(1), 59-64.

Mauthner, T., Koch, C., Tilp, M., & Bischof, H. (2007). Visual tracking of athletes in beach volleyball using a single camera. *International Journal of Computer Science in Sport, 6,* 21-34.

Miletić, Đ., Srhoj, LJ., & Bonacin, D. (1998). Influence of initial status of motor abilities on learning rhythmic gymnastics routines. *Kinesiology, 30*(2), 66-75.

Minvielle-Moncla, J., Audiffren, M., Macar, F., & Vallet, C. (2008). Overproduction timing errors in expert dancers. *Journal of Motor Behaviour, 40*(4), 291-300.

Mišigoj-Duraković, M., Matković, B. R., Ružić, L., Duraković, Z., Babić, Z., Janković, S., & Ivančić-Košuta, M. (2001). Body composition and functional abilities in terms of the quality of professional ballerinas. *Collegium antropologicum, 25*(2), 585-590.

Perš, J. (2001). *Sledenje ljudi z metodami računalniškega vida. [Tracking people with the methods of the computer vision.] Unpublished master's thesis.* Ljubljana: Faculty of electrical engineering.

Perš, J., Bon, M., Kovačič, S., Šibila, M., & Dežman, B. (2002). Observation and analysis of large-scale human motion. *Human Movement Science, 21,* 295-311.

Šibila, M., Vuleta, D., & Pori, P. (2004). Position-related differences in volume and intensity of large-scale cyclic movements of male players in handball. *Kinesiology, 36*(1), 58-68.

Uzunović S., & Kostić, R. (2005). A study of success in Latin American sport dancing. *Facta Universitatis Series: Physical Education and Sport, 3*(1), 23-35.

Verghese J. (2006). Cognitive and mobility profile of older social dancers. *The Journal of the American Geriatrics Society, 54,* 1241–1244.

Vučković, G., Perš, J., & Dežman, B. (2006). Razvoj avtomatskega sledenja gibanj igralcev na tekmah in obdelave zbranih podatkov. [The development of automatic tracking of the movements of athletes and methods of editing gathered data]. *Šport, 54,* 27-30.

Vučković, G., Perš, J., James, N., & Hughes, M. (2010). Measurement error associated with the SAGIT/squash computer tracking software. *European Journal of Sport Science, 10*(2), 129-140.

Zagorc, M. (2000). *Družabni in športni ples [Social and sport dance].* Ljubljana: PZS, ZPVUT.

Zagorc, M., & Zaletel, P. (1996). *Primerjava nekaterih morfoloških značilnosti in motoričnih sposobnosti plesalcev in plesalk športnega plesa in akrobatskega rock'n'rolla [Comparison of some morphologic and motor dimensions of female and male sport dancers].* Ljubljana: PZS.

Zagorc, M., Karpljuk, D., & Friedl, M. (1999). Analysis of functional loads of top sport dancers. In: Milanović (ed.), *Kinesiology for the 21st century. Proceedings book, Dubrovnik,* (pp. 240-244). Zagreb, Fakultet za fizičku kulturu.

Zaletel, P., Tušak, M., & Zagorc, M. (2006). *Plesalec – športnik in umetnik:* znanstvena monografija *[Dancer – an athlete and an artist].* Ljubljana: Faculty of Sport and ARRS.

Zaletel, P., Tušak, M., Tušak, M., & Zagorc, M. (2004). Pomen medsebojnih odnosov v športnem plesu [The importance of social interactions in sport dance]. *Anthropos. 36,* 1/4, 73-88.

Zaletel, P., Vučković, G., Rebula, A., & Zagorc, M. (2010). Analiza obremenitve plesnih parov pri izbranih standardnih in latinsko-ameriških plesih s pomočjo sledilnega sistema SAGIT [Analysis of the loads in selected standard and Latin-American dances through the tracing system SAGIT]. *Šport, 58*(3/4), 85-91.

Zhang, J. G., Ishikawa-Takata, K., Yamazaki, H., Morita, T., & Ohta, T. (2008). Postural Ssability and physical performance in social dancers. *Gait & Posture, 27,* 697–701.

Zucolotto, A., & Freire, A.L.G. (2003). A divina danca, www.idance.com.br, accessed 11 October, 2010.