

Personalized modification of sport dance wheelchairs

Monika Michalikova, Lucia Bednarcikova, Jana Demeterova, Jozef Zivcak

<https://doi.org/10.22306/atec.v9i4.180>

Received: 25 July 2023; Revised: 11 Oct. 2023; Accepted: 30 Nov. 2023

Personalized modification of sport dance wheelchairs**Monika Michalikova**

Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Technical University of Kosice, Letna 1/9, Kosice, 042 00, Slovak Republic, EU, monika.michalikova@tuke.sk (corresponding author)

Lucia Bednarcikova

Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Technical University of Kosice, Letna 1/9, Kosice, 042 00, Slovak Republic, EU, lucia.bednarcikova@tuke.sk

Jana Demeterova

Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Technical University of Kosice, Letna 1/9, Kosice, 042 00, Slovak Republic, EU, jana.demeterova@tuke.sk

Jozef Zivcak

Faculty of Mechanical Engineering, Department of Biomedical Engineering and Measurement, Technical University of Kosice, Letna 1/9, Kosice, 042 00, Slovak Republic, EU, jozef.zivcak@tuke.sk

Keywords: wheelchair, dance, sport, personalization.**Abstract:** Standard modifications of active wheelchairs are commonly performed, but they often do not take into account the individual needs of dancers. The presented article aims to propose the optimization and personalization of the Quickie Argon Ti dance wheelchair for a specific subject. A visualization of a personalized dance wheelchair was created, abiding by the dimensional frame. The quality of the performance of physically disabled individuals in sports dancing on wheelchairs is significantly influenced by its construction and parameters. In this article, a standard sports wheelchair, and the requirements placed on a sports wheelchair used for dancing were described. After addressing the shortcomings, the modifications of selected components of the disabled sports wheelchair were presented.**1 Introduction**

Wheelchair dancing is an activity that integrates a wheelchair user and a healthy dance partner. Wheelchair dancing was initially used for recreational and rehabilitation purposes. It was created in Sweden in 1968. Els - Britt Larsson, a wheelchair user who worked for the Swedish Federation for the Disabled, was one of the pioneers of the sport. Wheelchair dancing spread very quickly and became a popular sport, especially in Sweden.

In 1998, wheelchair dancing became an International Paralympic Committee (IPC) division but is not part of today's Paralympic program. It is under the organization of IPC and overseen by the Dance Technical Commission, which includes the rules of the World Dance Sports Federation (WDSF) [1].

Physical benefits of wheelchair dancing include maintaining body balance, flexibility, range of motion, coordination, and improved breathing. The psychological effect of dance is social interaction and the development of relationships. For beginners, it is an opportunity to join in a fun and friendly event with others. For advanced dancers, it helps in the development of the idea of "fair play", sportsmanship and communication skills [1].

Wheelchair dancing is a defined type of dance. Standard dances are waltz, tango, Viennese waltz, slow fox and quickstep. Latin American dances include samba, cha-cha, rumba, paso doble and jive.

Sports wheelchairs differ from regular wheelchairs in terms of design and components that improve personal

comfort and performance when engaging in physical activity. The frame is light for easy handling. The front wheels and the rear 5th or 6th wheel are of a similar type as used on roller skates. The 5th and 6th wheels are used to ensure stability and balance when manoeuvring. Depending on wheelchair setup, build and personal preference, the rear wheels range from 609.6 mm to 660.4 mm in diameter. They are also equipped with hoops and a footrest. The backrest can be adjusted to different heights depending on the level of functionality of the body. Those athletes who have an active upper body do not need a high backrest. They can sit higher than those who require more back support. The backrest reinforcement is adjustable as needed to provide the best possible back support. A suitable seat cushion is also important. Its size, thickness and shape can vary depending on the specific needs of each athlete [2].

2 Dancing wheelchair

The dance wheelchair is a joint combination of a basketball wheelchair and an active wheelchair [3]. Wheelchair basketball mixes brief, intensive exercise bursts of quick acceleration and deceleration, dynamic position adjustments, and maintaining or gaining one's place on the court [4]. The basketball sports wheelchair is the basic pillar for other sports wheelchairs. It is characterized by a large variability of the basic setting of the frame. This means that the center of gravity, height and inclination of the seat can be adjusted. The robust frame for

Personalized modification of sport dance wheelchairs

Monika Michalikova, Lucia Bednarcikova, Jana Demeterova, Jozef Zivcak

basketball wheelchair ensures safety and prescribed dimensions. The wheelchair is suitable for recreational and pro sports. The advantage of the basketball wheelchair is the inclination of the wheels of 16 to 20 degrees, which enables optimal stability and maneuverability.

The active wheelchair is available in different widths, depths and heights from the ground, with an integrated or folding front part, with connected self-folding and split footrests, with mudguards and board sides, as well as with different types of backrest.



Figure 1 *Qiciki Argon Ti* [3](A) and *Quickie Argon Ti* with modification for dance sports (B)

The dance wheelchair was inspired by the basketball wheelchair compactness and simplicity of its structure, the possibility of adjustment, whether the center of gravity or the height of the seat, the inclination of the wheels, and used materials. Also, as there is no need for rear handrails and brakes (depends on the user's requirements), armrests are replaced by the protective side panels. These are not only protecting the user from rotating wheels but are also defining the seat. Such parts save a significant amount of weight. The current trend in the development of the dance wheelchair is a move towards an all-welded frame, which

is easier to maintain. The center of gravity is located approximately at the axis of the seated person; however it depends on the dancing disposition and the requirements of the dancer. The closer the center of gravity is to the axis of the sitter, the more accurate rotations and better control the dance wheelchair is. A dance wheelchair means the same to a wheelchair user as legs to a healthy dance partner. The dance wheelchair in question, which is personalized, is based on the model of active wheelchair Quickie Argon Ti (Figure 1). Quickie Argon Ti modified for dance sports differs from the base model with a narrowed front frame, lowered backrest, compact front brakes, sport lightweight wheels and carbon sidewalls, luminous front wheels, and not included handles. Other modifications are the reduction of the inclination of the wheels from the original 9° to 6° and an adaptation by raising the seat to the level of the protective side panels. At the moment, the wheelchair is suitable with its settings, but changes within the modification could bring improvements in properties and weight reduction. It is used for both standard and Latin American dances in a combined couple.

2.1 Proposal for a modification of a sports wheelchair intended for dancing

Due to the possibility of a wide variety of modifications, there is a large number of screw connections. These need to be tightened more often when using the wheelchair for dancing. Loose screw connections are manifested on the wheelchair by "popping" sound. This means that the wheelchair emits the mentioned sound when crossing an unevenness or during a dynamic movement. The subsequent elimination of the problem is very time-consuming. Another disadvantage is the frame, which is fixed to the axle of the wheels via beams, and forms a mechanically stressed open system. The height of the backrest initially met the requirements. However, the development of dancing skills can cause the wheelchair user to be limited by it in dancing. The modifications of the dance wheelchair consist of replacing individual selected parts of the wheelchair with a stable, non-adjustable replacement and a modification of the frame into a mechanically stressed closed system. This achieved higher resistance and strength. Therefore, the problems with bolted joints were eliminated. A better transfer of torque from the wheels to the frame was obtained. This gives a better feeling of control over the handling of the wheelchair. Dural is an economically advantageous material for production, which also meets the prerequisites for the necessary functionality.

2.2 Modifications of individual components

In the Figure 2 (A) is the original adjustable construction. As it is better for the healthy partner to have the wheelchair higher and thus have better contact with the wheelchair user. The height of the beam was increased from the original 8 cm to 15 cm. The new beam is fixed and not adjustable.

Personalized modification of sport dance wheelchairs

Monika Michalikova, Lucia Bednarcikova, Jana Demeterova, Jozef Zivcak

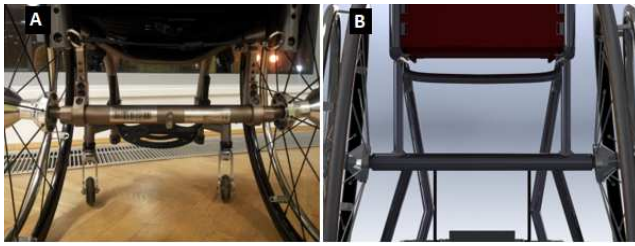


Figure 2 Beam before (A) and after modification (B)

The center of gravity (Figure 3) was satisfactory, the change was only the welding of the beam to the frame.



Figure 3 Center of gravity before (A) and after adjustment (B)

The modification (Figure 4) concerned the adaptation of the original frame to a mechanically closed structure. Which consisted in welding a part of the frame between the central axis and the front lower part of the frame.



Figure 4 Frame before (A) and after modification (B)

The inclination (Figure 5) of the wheel remained unchanged, as the characteristics of the truck were satisfactory. The hub was welded to the axis of the frame.



Figure 5 The inclination of the wheels was unchanged but fixed firmly

Better stability of the wheelchair (Figure 6) was ensured by changing the front wheels from 76.2 mm to 101.6 mm.

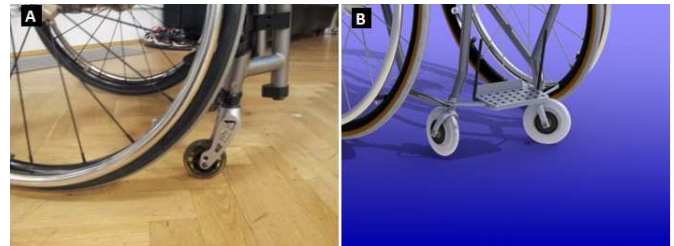


Figure 6 Front wheels before (A) and after modification (B)

Due to the dancer's weight loss, the seat part of the wheelchair was modified, which was narrowed by 15 mm on each side (Figure 7).



Figure 7 Original (A) and modified seat (B)

The reduction (Figure 8) of the backrest was due to better mobility of the upper part of the body. The folding backrest has been converted to a fixed one, which reduces the weight and improves the wheelchair's fitment into the seat.



Figure 8 The original height (A) of the backrest and its reduction (B)

3 Results and discussion

Finally, visualization was realized through the extension of the *Solidworks* software - *Photoview 360*. The dimensions of the wheelchair in question for the dimensional design of the modified components were obtained based on consultations with the distributor. Subsequently, the design part of the wheelchair and parts of the modifications were designed. Individual adjustments were also adapted after discussion with the user. Modeling of the wheel rim was done first. Subsequently, the mantle and hoop were modeled. Next, the modeling of the front wheel was continued, as the wheel size was first designed according to the catalog values. Then the fork of the wheel attachment was adapted. The bearings were chosen from the program superstructure, which can recalculate the required space for the bearing and select a suitable bearing

Personalized modification of sport dance wheelchairs

Monika Michalikova, Lucia Bednarcikova, Jana Demeterova, Jozef Zivcak

from the selected standard (Figure 9 - Figure 12). The same method was used to select bearings for large wheels. The core was the modeling of the frame, which consisted in modeling half of the frame and subsequent mirroring. In the end, we modeled: the axis of the wheels, the limiting ring, the screw with the nut for the small wheel, the seat, and the backrest. These dance wheelchair components were finally put into the *assembly* and a complete model was created, which was visually modified. Adaptive sports and recreation are among the most effective ways for improving results during medical rehabilitation, changing people's perceptions of themselves, and promoting broader inclusion of individuals with disabilities in society [5].



Figure 9 Front view

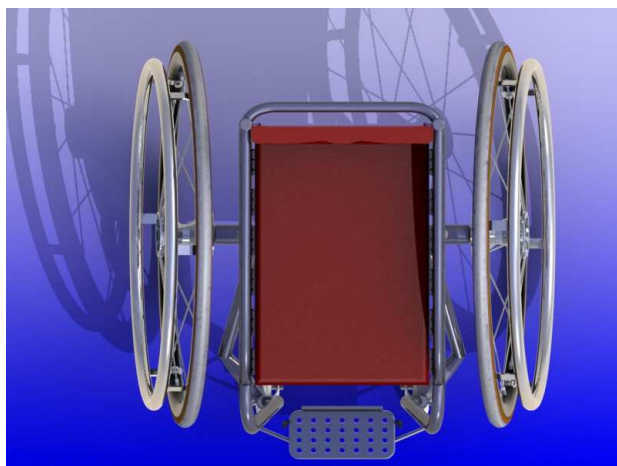


Figure 10 View from above



Figure 11 View from the left



Figure 12 Spatial view

4 Conclusions

As part of the personalization of the dance wheelchair, changes were in the beam, center of gravity, modification of the frame, attachment of the hub to the axis of the frame, replacement of the front wheels, narrowing of the seat, and lowering of the backrest. A higher resistance of the wheelchair to wear and tear and misalignment of individual settings during dance sports was achieved. Increasing the sitting position results in better interaction between the healthy partner and the seated wheelchair dancer.

The personalization of dance wheelchair contributes to the development of this sport and the increase of self-realization of disabled dancers.

Acknowledgement

This research was supported by project KEGA 044TUKE-4/2022 Implementation of progressive technologies in prosthetics and orthotics education and support integration with practice, KEGA 021TUKE-4/2022 “Implementation of computed tomography in an interdisciplinary technical-natural area”. This publication is the result of the project implementation Research and development of intelligent traumatological external fixation systems manufactured by

Personalized modification of sport dance wheelchairs

Monika Michalikova, Lucia Bednarcikova, Jana Demeterova, Jozef Zivcak

digitalisation methods and additive manufacturing technology (Acronym: SMARTfix), ITMS2014+: 313011BWQ1 supported by the Operational Programme Integrated Infrastructure funded by the European Regional Development Fund.

References

- [1] International Paralympic Committee, <https://www.paralympic.org>, Para Dance Sport - About the Sport, [Online], Available: <https://www.paralympic.org/dance-sport/about> [20 Jul 2023], 2020.
- [2] BC Wheel Chair Basketball Society, <https://www.bcwbs.ca/>, pushthegame™, [Online], Available: <http://www.bcwbs.ca/sites/default/files/users/images/WheelchairParts.jpg> [20 Jul 2023], 2020.
- [3] Letmo, <https://letmo.sk>, Aktívne invalidné vozíky, [Online], Available: <http://www.letmo.sk/aktivne-invalidne-voziky/quickie-argon-invalidny-vozik-aktivny> [20 Jul 2023], 2021. (Original in Slovak)
- [4] JAMES, J., KOSMOL, A., SKUCAS, K., BIDA, U.: Relationship Between Functional Classification Levels and Anaerobic Performance of Wheelchair Basketball Athletes, *Research Quarterly for Exercise and Sport*, Vol. 81, No. 1, pp. 69-73, 2010.
- [5] DUVALL, J., SATPUTE, S., COOPER, R., COOPER, R.A.: A review of adaptive sport opportunities for power wheelchair users, *Disability and Rehabilitation: Assistive Technology*, Vol. 16, No. 4, pp. 407-413, 2021. <https://doi.org/10.1080/17483107.2020.1767220>

Review process

Single-blind peer review process.