International Journal of Social Science and Humanity
Volume. 2, Number. 1 March 2025
e-ISSN : 3047-4825; p-ISSN :3047-4817, Hal. 146-160
DOI: https://doi.org/10.62951/ijss.v2i1.303
Available online at: https://international.appisi.or.id/index.php/IJSS

The Positive Effects of Implementing Motion Analysis and Sport Biomechanics Technologies in Young Tennis Athletes' Training: A Community Service Approach

Muchamad Arif Al Ardha [1*], Panji Bana [2], Dani Primanata [3], Mochamad Purnomo [4], Oce Wiriawan [5], Sauqi Sawa Bikalawan [6]
[1-6] Universitas Negeri Surabaya, Indonesia
e-mail: muchamadalardha@unesa.ac.id *

Abstract, *This study aims to evaluate tennis training in young athletes with the suitability of resources and techniques used by athletes. A qualitative method with a case study design was used in this research. The study involved 15 tennis athletes with an age range of 10-17 years, who followed a training program for beginners. The data collection process involves athletes and parents by using semi-structured interviews. The data were subjected to thematic analysis, including the process of identifying, analyzing, and interpreting the data. According to this study, implementing motion analysis and sport biomechanics into young tennis training enhances long-term skills, confidence, and performance while lowering injury rates. Athletes are inspired and dedicated to their training because the visualized feedback from captivating technology. Biomechanics and motion analysis may revolutionize young sports training by improving performance and establishing new benchmarks. These tech-enabled initiatives support young athletes' success while protecting their health and welfare.*

Keywords**:** *LTAD; parents; sports technology; sports injury; young tennis athletes;*

1. INTRODUCTION

Tennis is a sport that demands precision, agility, and endurance, making it essential for players to optimize their movements and techniques to perform at their best (AbdiOğlu et al., 2024). In youth tennis, where athletes are still developing their skills and physical abilities, the integration of advanced training methodologies becomes even more critical (Kolman et al., 2021). Among these methodologies, sport biomechanics and motion analysis technologies have emerged as powerful tools for enhancing performance, minimizing injury risks, and extending athletic careers (Forte et al., 2021; Knudson, 2021).

Biomechanics, the scientific study of movement, provides coaches and athletes with insights into the mechanics of tennis strokes, footwork, and overall body dynamics (Suprunenko, 2021). By understanding how muscles, joints, and bones work together to generate power and efficiency (Ma & Huo, 2022), athletes can refine their techniques to achieve greater accuracy and consistency (Lo & Hsieh, 2016). In order to promote long-term athletic growth, biomechanics also helps in pinpointing areas that require work and creating training plans that focus on particular shortcomings (Schack & Weigelt, 2007). Biomechanics is enhanced by the use of motion analysis technology, like as high-speed cameras and specialized software, which provide thorough, real-time feedback on an athlete's motions (Rodolfo Vastola et al., 2016). These resources give trainers the ability to identify technical

Received: February 14, 2025 ; Revised: February 28, 2025; Accepted: March 02, 2025; Online Available: March 06, 2025

errors or minor inefficiencies that might not be apparent to the unaided eye (Rigozzi et al., 2023). This accuracy is crucial for young tennis players because it enables individualized training based on their particular requirements and skill level.

This study focuses on using motion analysis and sport biomechanics technologies as part of a community service project for young tennis players in Surabaya. By equipping local coaches and players with state-of-the-art information and resources, the program aims to close the gap between scientific research and real-world application. In addition to improving young athletes' technical skills, the program encourages sustainable coaching methods by offering workshops and training sessions. By taking this method, the study hopes to address important issues in young tennis training, such as the predominance of injury-prone approaches and the lack of access to cutting-edge tools. Additionally, it supports larger initiatives to promote active lives and raise the bar for tennis instruction in the area. This program shows how community service may have a significant influence on the growth of future athletes by incorporating science and technology into grassroots sports.

2. MATERIALS AND METHODS

Study Design

In order to investigate the use of motion analysis and sport biomechanics in young tennis training, this study used a qualitative methodology, concentrating on the viewpoints of young players and their parents. Regarding the program's influence, efficacy, and accessibility, the technique places a strong emphasis on comprehending the participants' subjective experiences, attitudes, and views.

In order to provide a comprehensive analysis of the program's execution in a community tennis context, a case study design was used. A thorough grasp of the program's impact on training methods and athletic development was made possible by this method, which made it easier to gather detailed data from a variety of viewpoints, including young players and their parents.

Study Participant

Purposive sampling was used to pick the 15 tennis players, who ranged in age from 10 to 17. These athletes participated actively in the beginner-level training program for the previous two years. Additionally, the parents of the young athletes were consulted in order to get their thoughts on the program's perceived advantages, difficulties, and overall worth for their kids.

Data Collection

Semi-Structured Interviews were conducted Individually both for youth athletes and their parents. The interviews focused on their experiences with the program, perceived changes in performance or confidence, and their thoughts on the use of technology in training. Example questions for athletes included:

1. How has motion analysis technology improved your tennis skills, such as your serve or backhand?
2. What insights have you gained about your body movements and mechanics through this training?
3. Have you noticed any changes in your confidence level while playing tennis after the program? Can you provide an example?
4. What challenges did you encounter while using the technology during training sessions?
5. How useful was the feedback from motion analysis in helping you understand and improve your movements?
6. Was the technology easy or difficult to use during training? Did you feel it was accessible and clear?
7. Have you observed any improvements in your overall performance, like speed, accuracy, or endurance, since joining the program?
8. What are your thoughts on incorporating advanced technologies like motion analysis in tennis training? Do you think it makes a big difference?
9. Did the use of technology make the training sessions more engaging or enjoyable for you? Why or why not?
10. If you could suggest improvements or additions to the program, especially regarding technology, what would they be?

Example questions for parents included:

1. How do you feel about the inclusion of sport biomechanics in your child's tennis training program?
2. Have you noticed any improvements in your child's performance or confidence since the program began?
3. What aspects of the program do you think have been most beneficial for your child's development as an athlete?
4. How well do you think the coaches explained the role of biomechanics in improving your child's tennis skills?

5. Do you feel that using motion analysis technology makes the training more effective compared to traditional methods? Why or why not?
6. How has the program influenced your child's enthusiasm or interest in playing tennis?
7. What are your thoughts on the program's focus on injury prevention through biomechanics? Have you noticed any positive outcomes in this regard?
8. As a parent, do you feel more confident about your child's training knowing that advanced technologies like motion analysis are being used?
9. Are there any challenges or concerns you've observed regarding the use of sport biomechanics in your child's training?
10. Would you recommend this type of training program to other parents? What reasons would you give for your recommendation?

Thematic analysis was employed to identify, analyze, and interpret patterns within the qualitative data. The following steps were taken:

1. Familiarization: Audio recordings of interviews and focus groups were transcribed verbatim, and observational notes were reviewed to gain an initial understanding of the data.
2. Coding: Open coding was used to label key concepts and recurring ideas across the dataset.
3. Theme Development: Codes were grouped into themes that captured the overarching perspectives of youth athletes and their parents.
4. Interpretation: Themes were interpreted in the context of the study's objectives, highlighting how the program influenced training outcomes, attitudes toward technology, and perceptions of skill development.

This qualitative methodology offers a detailed comprehension of the program's effects, revealing significant insights into the experiences of adolescent athletes and their parents, while maintaining a participant-centered and contextually relevant framework.

3. RESULTS

The qualitative investigation into the application of sport biomechanics and motion analysis technology in the training of young tennis players yielded substantial insights from both the young athletes and their parents. The results are organized into principal categories identified through thematic analysis: skill enhancement, confidence and involvement, technological usability, accident avoidance, and parental perceptions of the program's worth. Each theme illustrates the diverse effects of the training program on the participants.

Skill Development

A significant topic was the enhancement in technical skills noted among youth athletes. The athletes consistently reported improved accuracy and effectiveness in their tennis strokes, especially in their serves, backhands, and footwork. The application of motion analysis technologies allowed for the identification of certain areas for enhancement, including body alignment, racket location, and movement patterns.

Numerous athletes indicated that the visual feedback provided by the motion analysis technology enhanced the efficacy of their training. One athlete stated, "Upon reviewing the replay of my serve, I recognized that my body positioning was incorrect, and rectifying it significantly enhanced my power." The athletes indicated that the capacity to observe and assess their motions in real-time enhanced their comprehension of how their body mechanics influenced their performance.

Moreover, the use of biomechanical concepts enabled the athletes to employ more energy-efficient approaches. Numerous participants saw that they could engage in prolonged play without experiencing fatigue, as they mastered the optimization of their movements and evaded superfluous exertion.

Confidence and Engagement

The program significantly influenced the athletes' confidence levels. A multitude of players indicated an increase in self-confidence on the court as they observed measurable enhancements in their abilities. A participant stated, *"I previously experienced anxiety during matches, but I now feel more equipped due to my enhanced technique."*

Alongside confidence, the athletes emphasized that technology enhanced the engagement and enjoyment of training sessions. The interactive characteristics of the motion analysis system sustained their motivation to engage and exert greater effort during drills. Athletes characterized the technology as "*entertaining*" and "*impressive*," with one athlete remarking, *"It resembles a game when you observe your movements on the screen."* It enhances the engagement of practice.

The integration of skill enhancement and stimulating training techniques fostered an increased sense of achievement and motivation among the athletes.

Technology Usability

The players acknowledged the new technology but also expressed concerns about its utility. Younger participants, specifically, sometimes encountered difficulties comprehending the technical output from the motion analysis system. Nevertheless, these obstacles were

alleviated by the coaches, who proficiently elucidated the data and its ramifications for their instruction.

An athlete stated, *"Initially, I did not comprehend the significance of the numbers and graphs, but the coach elucidated them effectively, making their application more manageable."* The athletes indicated that the technology was intuitive after acclimatization, and they appreciated its role in their educational development.

Injury Prevention

Both players and parents recognized the program's focus on injury prevention via biomechanics training. Athletes indicated acquiring appropriate ways to alleviate bodily strain, including modifications to their posture and grip to diminish joint tension. Numerous participants emphasized the significance of these courses in preventing prevalent tennis problems, including shoulder and elbow strain.

A parent remarked, "*Prior to the program, my child frequently expressed discomfort in the shoulder following matches*." They have acquired the ability to move more effectively, resulting in a significant reduction in pain. Parents expressed considerable appreciation for this feature, as it convinced them that their children were being educated with an emphasis on their long-term health and safety.

Parental Perspectives

The parents offered significant perspectives on the program's overall effect on their children. They collectively concurred that the incorporation of biomechanics and motion analysis had introduced a novel aspect to their children's training. Numerous parents observed considerable enhancements in their children's confidence, performance, and excitement for tennis.

A parent stated, "*I have observed my child becoming more focused and disciplined since enrolling in the program*." They consistently exhibit enthusiasm in sharing their acquired knowledge regarding their expertise. Parents valued the systematic feedback offered by the technology, as it afforded them a more lucid comprehension of their children's advancement.

Furthermore, parents appreciated the program's creative methodology and regarded it as establishing a superior benchmark for youth tennis training. A number of parents articulated a preference for broader implementation of analogous initiatives, highlighting the significance of integrating science and sports at the grassroots level. A parent remarked, "*This program transcends tennis; it aims to establish a foundation for success in both sports and life*."

Nevertheless, several parents expressed apprehensions over the possible difficulties of executing technology-driven training programs in under-resourced environments. They underscored the necessity for accessibility and affordability to enable a greater number of youth athletes to benefit from these developments.

Suggestions for Improvement

Both players and parents provided constructive critiques regarding potential enhancements to the program. Athletes proposed the integration of supplementary features in the motion analysis system, including comparative analysis with professional players, to augment their learning experience. Parents advocated for more frequent updates regarding their children's progress and increased participation in seminars or discussions concerning the technology.

A parent proposed, "*It would be beneficial to have sessions in which the coaches elucidate the concepts of biomechanics to us as parents*." This approach enables us to enhance our children's education at home. These recommendations underscore the opportunity for additional enhancement and expansion of the program to address the changing requirements of the participants.

4. DISCUSSION

This study highlights the significant influence of integrating sport biomechanics and motion analysis technologies into juvenile tennis instruction. These tools connect academic comprehension with actual implementation, providing a transforming experience for both athletes and parents (Gao et al., 2024; Morouço, 2024). This discourse examines the ramifications of the findings, underscores the overarching importance of such programs, identifies potential obstacles, and offers ideas for future executions.

The program significantly enhanced the technical capabilities of youth athletes. Athletes consistently indicated that the visual and data-driven feedback from motion analysis technologies enhanced their technique refinement beyond the capabilities of traditional coaching approaches. The accuracy provided by biomechanics training is especially beneficial for young athletes, as their techniques are still maturing (Yeadon & Pain, 2023). Inadequate practices acquired during formative stages can stay entrenched, resulting in diminished performance or potential injury in later stages of their careers (Bartlett & Bussey, 2013). By recognizing and resolving these concerns promptly, the program establishes a robust foundation for the athletes' sustained development (Balyi et al., 2013). Athletes indicated that the visual depiction of their motions generated a sense of ownership toward their training (Tang

et al., 2020). This empowerment motivated them to actively participate in their learning process, which is essential for cultivating engagement and commitment in young athletes (Zhang et al., 2024).

The curriculum significantly influenced the athletes' confidence and participation. Confidence is a crucial element in sports, affecting both athletes' performance and their reaction to obstacles and losses (Alp et al., 2021). The quantifiable advancements demonstrated by motion analysis furnished concrete proof of enhancement, reinforcing the players' confidence in their capabilities (Song et al., 2023). Numerous athletes indicated an increase in self-confidence on the court, resulting in enhanced performance during competitions. Furthermore, the interactive characteristics of the technology rendered training sessions more captivating and pleasurable (Richlan et al., 2023). Athletes characterized the experience as enjoyable and comparable to a game, which sustained their motivation and dedication to training. For young athletes, sustaining interest and motivation is essential, and the program effectively converted standard drills into engaging and significant learning experiences.

A crucial component of the program was its emphasis on injury prevention, which was well appreciated by both athletes and parents. The software reduced dangers linked to repetitive strain and poor mechanics by instructing athletes on correct approaches and offering data-driven analyses of their actions (Navarro et al., 2021). Parents, specifically, conveyed their gratitude for this component of the program, highlighting that it alleviated their concerns regarding their children's safety while engaging in the sport. A number of parents saw a substantial decrease in their children's reports of physical discomfort, including shoulder pain, following the implementation of the effective movement patterns instructed in the program. This emphasis on long-term health and well-being corresponds with overarching trends in youth sports, which highlight the necessity of balancing performance objectives with the physical and emotional welfare of young athletes (Beaudoin et al., 2015).

Parental viewpoints contributed a crucial aspect to the study, elucidating perceptions of the program from a wider, non-participant viewpoint. Parents collectively concurred that the incorporation of biomechanics and motion analysis substantially enhanced their children's training. They noted enhancements in their children's confidence, performance, and excitement for tennis, thereby affirming the program's efficacy. Parents emphasized the significance of structured, evidence-based feedback, since the visual aspect of the motion analysis equipment facilitated their comprehension of their children's improvement. This transparency cultivated trust in the program and improved their satisfaction with its overall methodology (Makhov et al., 2019).

Nevertheless, several parents expressed apprehensions over the accessibility and scalability of these services. The expense of deploying motion analysis systems and the necessary resources for their operation were perceived as significant obstacles, especially in under-resourced communities (Lee & Park, 2022). This issue underscores the necessity for efforts to enhance the accessibility of these sophisticated training resources (Jamieson & Wijesundara, 2025). Creating cost-effective alternatives or funding initiatives for low-income families could guarantee that a greater number of youth athletes benefit from these advancements (van Leeuwen et al., 2023).

The effective application of sport biomechanics and motion analysis technologies in this program highlights their capacity to transform youth sports training (De Froda et al., 2016). These tools establish a more empirical and data-centric methodology for coaching, transcending conventional techniques that frequently depend on subjective observation (Waters et al., 2019). Furthermore, the curriculum corresponds with the growing professionalization of young sports. As competition intensifies, the demand for sophisticated training approaches increases, and programs that integrate such technology provide athletes with a competitive advantage while emphasizing their long-term development (Thomas & Gilbert, 2016). The fundamentals of biomechanics and motion analysis are relevant to various sporting activities (Tai et al., 2023). Extending the application of these methods to further sports may yield comparable advantages, including improved performance (Huang et al., 2022), injury prevention (Kim et al., 2022), and increased engagement, thereby transforming youth sports as a whole (Loya et al., 2023).

Notwithstanding its achievements, the program had numerous hurdles. Junior players often found it challenging to comprehend the feedback from the motion analysis system, underscoring the necessity for coaches to communicate effectively. Coaches must serve as middlemen between technology and athletes, guaranteeing that the data is both accessible and actionable (Conners et al., 2018). It is essential to train coaches to analyze and articulate data clearly and pertinently for athletes of diverse ages and ability levels (Choi et al., 2016). A other potential concern is the danger of over dependence on technology. Although motion analysis offers significant insights, it ought to enhance rather than supplant the human aspect of coaching. Achieving equilibrium between technology-driven and coach-driven training is crucial for preserving a comprehensive approach (Sarmento et al., 2021).

Expense constitutes a substantial obstacle to the widespread implementation of such systems. Motion analysis systems necessitate a significant cost commitment, which may be impractical for all training facilities (Bortolan et al., 2023). Investigating economical

alternatives or pursuing sponsorships and partnerships may alleviate this difficulty and enhance the accessibility of these activities (Rajesh et al., 2020). Furthermore, public and commercial stakeholders should cooperate to finance these programs, guaranteeing that athletes from various socioeconomic backgrounds have use innovative training technology.

To enhance the efficacy of this program, multiple recommendations may be proposed. Initially, endeavors should be undertaken to enhance the accessibility of motion analysis instruments. This may involve creating cost-effective variants of the technology or providing subsidized initiatives for disadvantaged populations. Secondly, parental engagement should be improved through workshops that inform parents about biomechanics and ways to assist their children's training at home. Third, the technology might be enhanced to deliver more customized feedback, including comparative evaluations with elite athletes or individualized training regimens. The approach could ultimately be modified for many sports to enhance the influence of biomechanics on young players in diverse disciplines.

Limitations

This study possesses numerous shortcomings that warrant acknowledgment. The sample size was limited, comprising only 15 youth athletes and their parents. The qualitative technique provided in-depth insights, although the findings may lack full generalizability to larger populations. The purposive sample strategy, although helpful in identifying pertinent participants, constrains the diversity of opinions, especially from athletes with higher ability levels or from varied geographic regions. The study concentrated solely on tennis training, indicating that the relevance of the findings to other sports is unexamined.

Moreover, the brief duration of the program restricted the ability to evaluate long-term effects, including enduring performance enhancements or injury prevention results. The study emphasized difficulties in the first comprehension and application of motion analysis technologies, especially among younger athletes, indicating a necessity for enhanced training and onboarding procedures for both participants and coaches. Mitigating these constraints in forthcoming research will enhance the understanding of the efficacy and scalability of biomechanics-based training programs.

Recommendations

Based on the findings, the following recommendations are proposed to enhance the implementation of biomechanics and motion analysis technologies in youth sports:

1. **Increase Accessibility**

Develop cost-effective versions of motion analysis systems or offer subsidized programs to ensure that athletes from diverse socioeconomic backgrounds can benefit. Public-private partnerships and sponsorships could also be explored to fund these initiatives.

2. **Coach Training**

Provide comprehensive training for coaches to effectively interpret and communicate the data generated by the technology. This ensures that athletes, regardless of age or skill level, can fully understand and apply the feedback.

3. **Parental Involvement**

Conduct workshops or informational sessions for parents to familiarize them with biomechanics principles and how they can support their children's training. This engagement can enhance the program's impact both on and off the court.

4. **Expand to Other Sports**

Adapt the program to other sports where biomechanics and motion analysis could play a critical role in performance optimization and injury prevention, thereby extending its benefits to a broader athletic community.

5. **Long-Term Impact Studies**

Conduct longitudinal research to evaluate the sustained effects of biomechanics training on performance, injury prevention, and athlete retention. Such studies could provide deeper insights into the long-term value of these programs.

By addressing these recommendations, future programs can build upon the success of this initiative, ensuring that biomechanics and motion analysis technologies become a cornerstone of youth sports training worldwide.

5. CONCLUSIONS

This study emphasizes the substantial influence of incorporating sport biomechanics and motion analysis technologies into youth tennis training. The program improved performance, increased confidence, and promoted long-term skill development by helping players comprehend their body mechanics and polish their techniques. Athletes exhibited enhanced accuracy, energy optimization, and injury mitigation techniques, facilitating their whole athletic development. Moreover, the captivating and interactive characteristics of the technology sustained the players' motivation and dedication to their training.

Parental viewpoints highlighted the program's overarching significance, as parents observed concrete enhancements in their children's performance and enthusiasm. The

program's structured, evidence-based feedback enhanced trust in the training process. Nonetheless, apprehensions over accessibility, expense, and early usefulness of the technology underscore areas necessitating enhancement, especially in rendering such programs broadly accessible to varied people.

The results highlight the transformative capacity of biomechanics and motion analysis in athletics, both for enhancing individual performance and for establishing elevated benchmarks in juvenile sports training. With the ongoing professionalization of youth sports, technology-driven programs provide a vital advantage, allowing young players to thrive while emphasizing their health and well-being.

Acknowledgment

We extend our heartfelt appreciation to Universitas Negeri Surabaya for supplying the essential resources and facilities for this research. We express our gratitude to the 15 young tennis athletes and their parents for their wonderful involvement and invaluable perspectives. We express our gratitude to all members of the study team for their committed support in data collecting and processing.

Conflict of interest

The authors declare there is no conflict of interest in this research.

References

AbdiOğlu, M., Hakkı, M. O. R., & Ahmet, M. O. R. (2024). Field and Court-Based Tests Used in the Determination of Physical Performance in Tennis. In *International Journal of Disabilities Sports and Health Sciences* (Vol. 7, Issue 1). https://doi.org/10.33438/ijdshs.1315076

Alp, A. F., Tasçioglu, R., Kocaeksi, S., & Sezer, U. (2021). Investigation of the Relationship between the Coach - Athlete Relationship and Sport Confidence in Adolescent Elite Taekwondo Athletes. *Pamukkale Journal of Sport Sciences*, *12*(2), 17–28. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85125713768&partnerID=40&md5=accf937c7ffe1f81d33d0747ff1ace89

Balyi, I., Way, R., & Higgs, C. (2013). *Long-Term Athlete Development* (M. Schrag, Ed.; 1st ed.). Human Kinetics Publishers Inc.

Bartlett, R., & Bussey, M. (2013). *Sports Biomechanics: Reducing Injury Risk and Improving Sports Performance* (2nd ed.). Routledge.

Beaudoin, C., Callary, B., & Trudeau, F. (2015). Coaches' Adoption and Implementation of Sport Canada's Long-Term Athlete Development Model. *SAGE Open*, *5*(3). https://doi.org/10.1177/2158244015595269

Bortolan, L., Savoldelli, A., Schena, F., Zoppirolli, C., Modena, R., & Pellegrini, B. (2023). Development of a Low-Cost System for Analytical Performance Analysis in Alpine Skiing. *2023 IEEE International Workshop on Sport, Technology and Research, STAR 2023 - Proceedings*, 104–109. https://doi.org/10.1109/STAR58331.2023.10302441

Choi, Y.-J., Cho, G.-S., & Kim, I.-G. (2016). The relationship between the coaching knowledge of the Taekwondo instructors and satisfaction and loyalty of the trainees. *Indian Journal of Science and Technology*, *9*(46). https://doi.org/10.17485/ijst/2016/v9i46/107179

Conners, R. T., Whitehead, P. N., Shimizu, T. S., & Bailey, J. D. (2018). Coaching and Technology: Live Team Monitoring to Improve Training and Safety. *Strategies*, *31*(5), 15–20. https://doi.org/10.1080/08924562.2018.1490230

De Froda, S. F., Thigpen, C. A., & Kriz, P. K. (2016). Two-dimensional video analysis of youth and adolescent pitching biomechanics: A tool for the common athlete. *Current Sports Medicine Reports*, *15*(5), 350–358. https://doi.org/10.1249/JSR.0000000000000295

Forte, P., Neiva, H. P., & Marinho, D. A. (2021). Sports biomechanics: Monitoring health and performance. *Journal of Men's Health*, *17*(4), 4–6. https://doi.org/10.31083/jomh.2021.105

Gao, Z., Chee, C. S., Norjali Wazir, M. R. W., Wang, J., Zheng, X., & Wang, T. (2024). The role of parents in the motivation of young athletes: a systematic review. *Frontiers in Psychology*, *14*, 1291711. https://doi.org/10.3389/FPSYG.2023.1291711

Huang, T.-Y., Tang, W.-T., Liu, T.-T., Hamill, J., & Hu, C. (2022). Kinematic and kinetic demands on better roundhouse kick performances. *Sports Biomechanics*. https://doi.org/10.1080/14763141.2022.2122862

Jamieson, A. R., & Wijesundara, H. D. (2025). A review of adaptive equipment and technology for exercise and sports activities for people with disabilities. *Disability and Rehabilitation. Assistive Technology*, *20*(1). https://doi.org/10.1080/17483107.2024.2372323

Kim, K., Davaasambuu, B., Wei, R., & Kim, Y. H. (2022). Biomechanical investigation of anterior cruciate ligament injury risk in pivoting leg during taekwondo kicks using motion analysis system. *Journal of Mechanical Science and Technology*, *36*(2), 1051–1056. https://doi.org/10.1007/s12206-022-0150-6

Knudson, D. (2021). Fundamentals of biomechanics. In *Fundamentals of Biomechanics*. https://doi.org/10.1007/978-3-030-51838-7

Kolman, N. S., Huijgen, B. C. H., Visscher, C., & Elferink-Gemser, M. T. (2021). The value of technical characteristics for future performance in youth tennis players: A prospective study. *PLoS ONE*, *16*(1 January). https://doi.org/10.1371/journal.pone.0245435

Lee, K. Do, & Park, H. S. (2022). Real-Time Motion Analysis System Using Low-Cost Web Cameras and Wearable Skin Markers. *Frontiers in Bioengineering and Biotechnology*, *9*, 790764. https://doi.org/10.3389/FBIOE.2021.790764

Lo, K. C., & Hsieh, Y. C. (2016). Comparison of ball-and-racket impact force in two-handed backhand stroke stances for different-skill-level tennis players. *Journal of Sports Science and Medicine*, *15*(2).

Loya, A. K., Smith, P. E., Chan, D. D., Corr, D. T., & Drazan, J. F. (2023). Can biomechanics turn youth sports into a venue for informal STEM engagement? *Journal of Biomechanics*, *148*. https://doi.org/10.1016/j.jbiomech.2023.111476

Ma, Q., & Huo, P. (2022). Simulation analysis of sports training process optimisation based on motion biomechanical analysis. *International Journal of Nanotechnology*, *19*(6–11), 999–1015. https://doi.org/10.1504/IJNT.2022.128982

Makhov, A. S., Medvedev, I. N., Mikhailova, I. V, & Alifirov, A. I. (2019). Psychological satisfaction of parents of young football players with a mosaic form of down syndrome by the quality of sports training. *Prensa Medica Argentina*, *105*(8), 477–482. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85077595863&partnerID=40&md5=a4a8c7f0378e1b4e9eec745510930377

Morouço, P. (2024). Wearable Technology and Its Influence on Motor Development and Biomechanical Analysis. *International Journal of Environmental Research and Public Health*, *21*(9), 1126. https://doi.org/10.3390/IJERPH21091126

Navarro, E., Navandar, A., Veiga, S., & San Juan, A. F. (2021). Applied biomechanics: Sport performance and injury prevention. *Applied Sciences (Switzerland)*, *11*(9), 13–14. https://doi.org/10.3390/app11094230

Rajesh, P., Pranav Anand, P., Rupesh Babu, C., Karthik, V., & Kumar, A. (2020). Affordable human motion analysis system. *IOP Conference Series: Materials Science and Engineering*, *912*(6), 062025. https://doi.org/10.1088/1757-899X/912/6/062025

Richlan, F., Weiß, M., Kastner, P., & Braid, J. (2023). Virtual training, real effects: a narrative review on sports performance enhancement through interventions in virtual reality. *Frontiers in Psychology*, *14*, 1240790. https://doi.org/10.3389/FPSYG.2023.1240790

Rigozzi, C. J., Vio, G. A., & Poronnik, P. (2023). Application of wearable technologies for player motion analysis in racket sports: A systematic review. In *International Journal of Sports Science and Coaching* (Vol. 18, Issue 6). https://doi.org/10.1177/17479541221138015

Rodolfo Vastola, Silvia Coppola, & Maurizio Sibilio. (2016). Motion Analysis Technologies for Biomechanical Gait and Postural Analysis in Ballet. *Journal of Sports Science*, *4*(4). https://doi.org/10.17265/2332-7839/2016.04.008

Sarmento, H., Clemente, F. M., Field, A., & Miguel, P. A. S. (2021). Coaching efficacy and the use of technology. In *Coaching for Human Development and Performance in Sports* (pp. 353–369). Springer International Publishing. https://doi.org/10.1007/978-3-030-63912-9_18

Schack, T., & Weigelt, M. (2007). Representation of complex motor skills in long-term-memory. *Journal of Sport & Exercise Psychology*, *29*.

Song, Y., Sárosi, J., Cen, X., & Bíró, I. (2023). Human motion analysis and measurement techniques: current application and developing trend. *Analecta Technica Szegedinensia*, *17*(2), 48–58. https://doi.org/10.14232/ANALECTA.2023.2.48-58

Suprunenko, M. (2021). Biomechanical substantiation of motor and punch action formation in tennis by taking into account the formation of promising skills and abilities. *Journal of Physical Education and Sport*, *21*(1). https://doi.org/10.7752/jpes.2021.01035

Tai, W. H., Zhang, R., & Zhao, L. (2023). Cutting-Edge Research in Sports Biomechanics: From Basic Science to Applied Technology. *Bioengineering*, *10*(6), 668. https://doi.org/10.3390/BIOENGINEERING10060668

Tang, Y., Lu, J., & Zhou, J. (2020). Comprehensive Instructional Video Analysis: The COIN Dataset and Performance Evaluation. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *43*(9), 3138–3153. https://doi.org/10.1109/tpami.2020.2980824

Thomas, S. V., & Gilbert, J. E. (2016). Integrating Technology to Enhance Athlete Development: A Literature Review. *Journal of Higher Education Athletics & Innovation*, *1*, 73–84. https://doi.org/10.15763/ISSN.2376-5267.2016.1.1.73-84

van Leeuwen, L., Ruiter, A., Visser, K., Lesscher, H. M. B., & Jonker, M. (2023). Acquiring Financial Support for Children's Sports Participation: Co-Creating a Socially Safe Environment for Parents from Low-Income Families. *Children*, *10*(5), 872. https://doi.org/10.3390/CHILDREN10050872

Waters, A., Phillips, E., Panchuk, D., & Dawson, A. (2019). The coach–scientist relationship in high-performance sport: Biomechanics and sprint coaches. *International Journal of Sports Science and Coaching*, *14*(5), 617–628. https://doi.org/10.1177/1747954119859100

Yeadon, M. R., & Pain, M. T. G. (2023). Fifty years of performance-related sports biomechanics research. *Journal of Biomechanics*, *155*, 111666. https://doi.org/10.1016/J.JBIOMECH.2023.111666

Zhang, X., Rogers, M., & Werthner, P. (2024). Exploring a practitioner-athlete relationship and facilitated learning throughout a psychological skills training program. *Frontiers in Psychology*, *15*, 1354129. https://doi.org/10.3389/FPSYG.2024.1354129