Journal of Coaching and Sports Science
Volume 3, Issue 2, 113-121.
e_ISSN: 2963-1483
https://www.journal.foundae.com/index.php/jcss/index

The Effect of Groundstroke Forehand Exercise on Speed and Agility in 14 to 16-year-old Tennis Athletes

Rices Jatra*
Universitas Negeri Padang, INDONESIA

Alnedral
Universitas Negeri Padang, INDONESIA

Kamal Firdaus
Universitas Negeri Padang, INDONESIA

Nagoor Meera Abdullah
Universiti Teknologi MARA, MALAYSIA

Alexandre Sibomana
University of Burundi, BURUNDI

Article Info

Article history:
Received: March 31, 2024
Revised: April 26, 2024
Accepted: June 10, 2024

Keywords:
Forehand drive;
Speed;
Agility.

Abstract

This research addresses gaps by developing a holistic training model that integrates essential elements for optimal tennis performance. The study explores how physical conditioning can enhance agility, speed, and overall performance of junior athletes aged 14 to 16, focusing on forehand drive. The aim is to provide insights for coaches and players by integrating physical and technical training to improve performance. The scope includes evaluating the effectiveness of a forehand drive training program supplemented with speed and agility exercises for junior tennis players. An experimental one-group pre-test-post-test design was employed. Eleven tennis athletes from the Nusalima Tennis Academy participated. Speed was measured using a 20-meter sprint, and agility was calculated using the 505 Agility Test. The training program spanned 12 sessions over four weeks. Statistical analysis included mean, standard deviation, normality tests, and t-tests. Pre-test and post-test results showed significant improvements in speed and agility. The t-test values indicated statistical significance, confirming the effectiveness of the forehand drive training model. Players demonstrated enhanced neuromuscular adaptation, muscle strength, coordination, and reaction time. The study concludes that the forehand drive training model significantly improves speed and agility in junior tennis players. The findings support the theory that focused and structured training enhances physical abilities and performance. Additionally, the research highlights the long-term health benefits of intensive tennis training, such as improved cardiovascular health and overall fitness. The training model can be widely applied to develop well-rounded athletes in tennis programs.

To cite this article: Jatra, R., Alnedral., Firdaus, K., Abdullah, N. M., & Sibomana, A. (2024). The effect of groundstroke forehand exercise on speed and agility in 14 to 16-year-old tennis athletes. *Journal of Coaching and Sports Science, 3*(2), 113-121. https://doi.org/10.58524/002024335800

INTRODUCTION

This research aims to address gaps in existing studies by developing a holistic training model that integrates all essential elements for optimal tennis performance (Michel et al., 2023; Reid et al., 2007). Focusing on a specific training model for the forehand drive, this study intends to explore how physical conditioning can be integrated into technical training to enhance agility, speed, and overall performance (Navia et al., 2022; Reid & Schneiker, 2008; Seeley et al., 2011; Zaferanieh et al., 2021). The forehand drive, a crucial element in tennis, necessitates a comprehensive training approach to maximize its effectiveness. This holistic approach is expected to provide valuable insights for coaches and players, especially junior athletes, to improve their training regimens and achieve better performance outcomes (Domínguez et al., 2021; Fleming et al., 2018; Gomes et al., 2013).

Despite extensive research on the physical and technical demands of tennis, there is limited focus on a holistic approach to training that combines all necessary elements for optimal performance (Dewanti et al., 2018; Deng et al., 2023; Ulbricht et al., 2016). Most studies have concentrated on physical conditioning and the kinematic aspects of the sport, often neglecting the integration of these elements into a comprehensive training model (Kolman et al., 2019; Munivrana et al., 2015; Unierzyski & Crespo, 2008). Furthermore, integrating physical and technical training is vital for developing well-rounded athletes. Additionally, there is a lack of research on junior athletes

*** Corresponding author:**
Jatra, R., Universitas Negeri Padang, INDONESIA, ricesjatra@edu.uir.ac.id

and how specific training models, such as forehand drive training, can enhance their performance by improving their physical and technical abilities.

Some studies on tennis indicate that the sport demands significant physical conditioning due to bursts of short activity followed by recovery periods during matches (Rutherford, 2017; Siekańska et al., 2021). This sport requires a combination of physical and technical skills, including strength, endurance, speed, agility, and strong metabolic pathways (Ferrauti et al., 2018; Genevois, 2019; Granacher & Borde, 2017; Lorenz et al., 2013; Wormhoudt et al., 2017). Studies have highlighted kinematic differences in various strokes and the importance of physical conditioning for optimal performance (Murphy & Häger, 2015; Rana & Mittal, 2021). Therefore, a focus on comprehensive physical conditioning is crucial for achieving peak performance. Furthermore, tennis has been shown to offer various health benefits, including better bone health and reduced cardiovascular risk (Chao et al., 2021; Jackson et al., 2020; Roetert et al., 2009). However, it is also noted that performance depends not only on physical conditioning but also on technique, tactics, mentality, training, facilities, and nutrition (Pol et al., 2020; Russell & Kingsley, 2014; Mencia et al., 2024; Thomas et al., 2016).

One important stroke in tennis is the forehand (Bahamonde & Knudson, 2003; Delgado-García et al., 2019; Genevois et al., 2020; Ohguni et al., 2009). The forehand is the second most important stroke in tennis after the serve, with players constantly attempting to dominate points (Roetert et al., 1992). Mastering the forehand drive is essential for gaining a competitive edge in matches. Forehand drive cross-court (CC) and down-the-line (DL) (Elliott et al., 1989; Landlinger et al., 2010) have been the focus of kinematic studies in tennis and table tennis. Recent studies show several kinematic differences between CC and DL shot directions, such as racket speed, hip alignment, shoulder alignment, and knee and elbow flexion (Lanzoni et al., 2018), providing valuable information to tennis coaches. Although the forehand drive is mostly executed from the forehand side of the court, advanced players can cover up to 85% of the court with their forehand and use it to produce more "winning" shots (Martin-Lorente et al., 2017). Therefore, this research should align with current developments where a holistic approach to training should be developed, such as providing forehand drive training supplemented with speed and agility. This research emphasizes forehand drive training incorporating speed and agility for tennis players aged 14 to 16.

METHOD

This research employed the experimental method with a one-group pre-test-post-test design. This method can be used to conduct experiments to look for cause and effect or the influence of other variables (Creswell, 2010).

Table 3. Research Design

Pre Tes	Exercise	Post-test
Y1) Speed	(X) Forehand Drive Exercise	(Y3) Speed
(Y2) Agility		(Y4) Agility

Information:
Y1 : Speed Pre-test Value
Y2 : Speed Pre-test Value
X : Treatment
Y3 : Speed Post Test Score
Y4 : Agility Post Test Score

The population in this study were eleven tennis athletes from the Nusalima Tennis Academy (ATN) Pekanbaru. The sample is the entire population because the sampling technique used is total. Data researchers used the bleep test as a research instrument. The Bleep test quantitatively measures speed with a 20-meter sprint and agility with the 505 Agility Test. The data collection technique uses pre-test and post-test, where the post-test is carried out at the beginning of the meeting, and the post-test is carried out at the end of the meeting or the 14th meeting. The analysis is carried out quantitatively with statistical tests. The procedure is to calculate each test's average and standard deviation, carry out the Lilliefors normality test, and test the difference in sample means (t-test). The following is the research procedure.

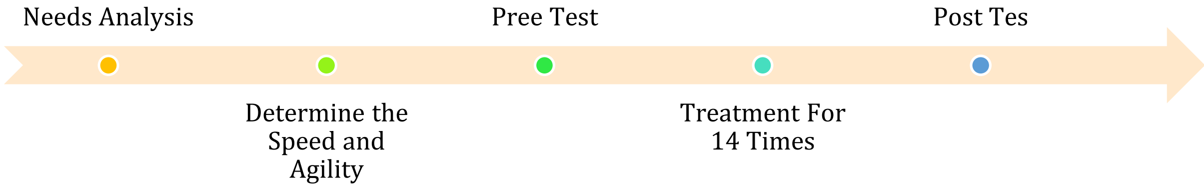

Figure 2. Research Design

RESULTS AND DISCUSSION

Result

After determining the sample, an initial test was carried out (pre-test) on the sample group. The instruments used were ability tests, speed tests, and agility tests. The pre-test was done to obtain initial data to reference whether the sample experienced increased speed and agility after being given the training program. The treatment was conducted over 12 meetings (4 weeks) with a training frequency of three times a week on Wednesday, Saturday, and Sunday. The players' training process ended with a final test *(post-test)*.

Table 2. The Frequency Data Distribution of Pre-test and Post-test on Speed (Nusalima Tennis Academy)

Speed (s)	Frequency of Pre-test		Frequency of Post-test		Category
	Absolute (Fi)	Relative(%)	Absolute(Fi)	Relative(%)	
3,21-3,58	3	27,27%	7	63,63%	Poor
3,59-3,95	6	45,55%	2	18,18%	High
3,96-4,32	2	18,18%	1	9,09%	Excellent
Total	10	100%	10	100%	

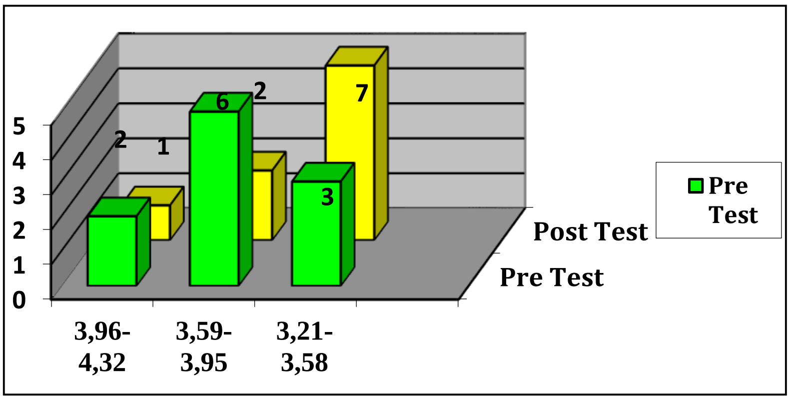

Figure 1. Pre-test and Post-test on Speed

Table 2. The Frequency Distribution Data of Pre-test and Post-test on Agility (Nusalima Tennis Academy)

Speed (s)	Frequency of Pre-test		Frequency of Post-test		Category
	Absolute (Fi)	Relative (%)	Absolute(Fi)	Relative (%)	
9,41-10,34	4	36,36%	5	45,45%	Poor
10,35-11,28	5	45,45%	5	45,45%	High
11,29-12,22	2	18,18%	1	9,09%	Excellent
Total	10	100%	10	100%	

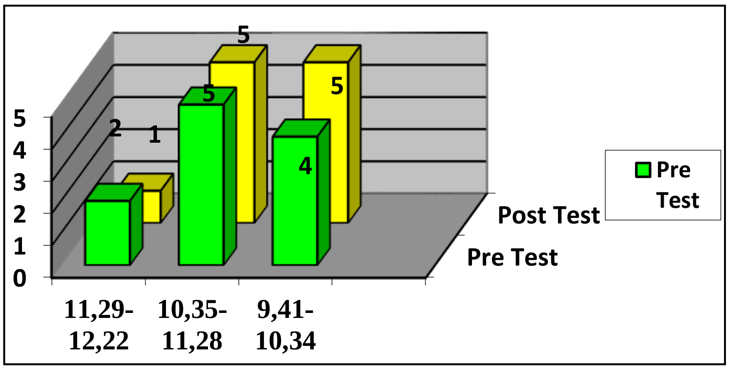

Figure 2. Pre-test and Post-test on Agility

Before testing the proposed hypothesis, the data analysis requirements are first tested, namely testing the normality of each data from the variables using the Lilliefors test. For more details, see Table 5.

Table 5. Summary of Data Distribution Normality Test

No	Variable	N	It	Ltab	Distribution
1	Speed Pre-test	11	0,1482	0,249	Normal
2	Speed Post-test	11	0,2274	0,249	Normal
3	Agility Pre-test	11	0,0927	0,249	Normal
4	Agility Post-test	11	0,0927	0,249	Normal

The table shows the normality test results for the post-test data. The sample group given the forehand drive training treatment came from a normally distributed population.

The Pre-test and Post-test on Speed

Initial test results (pre-test) speed of tennis players with a sample size of 11 people obtained the highest value of 3.22, the lowest value of 4.3, the average *(*mean*)* of 3.78, and the standard deviation (SD) of 0.3216. Furthermore, the final test results *(*post-test*)* with a sample size of 11 people obtained the highest value of 3.21, the lowest value of 4.29, the average (mean) of 3.62 from all total sample values, and the standard deviation (SD) of 0.3189. The test of the effect of forehand drive training to increase speed can be seen in the table below:

Table 6. The Summary of Test Results on the Effect of Training Models

Post-test	**3,62**	**0,319**	***Post-test***	**3,62**	**0,319**	***Post-test***
Pre-test	3,78	0,322	2,50	0,05	2,23	Significant
Post-test	3,62	0,319				

Based on the table above, it can be seen that $t_{observed}$ (2,50) is higher than $t_{critical}$ (2.23). Thus, it can be concluded that the forehand drive training model can improve the forehand drive of field tennis players.

The Pre-test and Post-test on Agility

Initial test results (pre-test) on *the a*gility of tennis players with a sample size of 11 people obtained the highest score of 9.41, the lowest score of 12.19, the average score (mean) of 10.71, and the standard deviation (SD) of 0.835. Furthermore, the final test results (post-test) show with a sample size of 11 people obtained the highest value of 9.39, the lowest value of 11.43, the average score (mean) of 10.46 of all total sample values, and the standard deviation (SD) of 0.623. The test of the effect of forehand drive training to improve agility can be seen in the table below:

Table 7. The Summary of Test Results on the Effect of Training Models

Group	**Mean**	**SD**	$t_{observed}$	**A**	$t_{critical}$	**Test results**
Pre-test	10,71	0,835	3,172	0,05	2,23	Significant
Post-test	10,46	0,623				

Based on the table above, it can be seen that $t_{observed}$ (2,50) is higher than $t_{critical}$ (2.23). Thus, it can be concluded that the forehand drive training model can improve the forehand drive of field tennis players. Based on the pre-test and post-test results, forehand groundstroke training effectively increases speed and agility. The relationship between ball speed and accuracy is important because these factors seem important for future abilities (Kolman et al., 2019). According to the speed-accuracy trade-off hypothesis, increasing the execution time of a movement is necessary to achieve greater accuracy (Gueugneau et al., 2017). Tennis has developed into a physically demanding sport with strong groundstrokes and explosive serve speed (Abdioglu et al., 2024). Motor skills, including strength, power, agility, speed, mental alertness, and highly developed neuromuscular coordination abilities, have also been associated with tennis performance (Girard & Millet, 2009; Ulbricht et al., 2016). Modifying training exercises can improve overall performance according to the characteristics of tennis matches in the 14–16-year age group and the athlete's physical condition. The modifications focus on the basics of the tennis forehand, which are then modified into six different exercise variations. With the training model and data from pre-test and post-test results using the 20-meter sprint test and 505 agility test, coaches or athletes can use it during training. Then, in the training, there is an element of agility, where the athlete will shift to the right or left and step forward or backward. This will increase agility.

Discussion

The results of this study are consistent with the theory that forehand drive training can enhance the physical abilities of tennis athletes. According to Dufresne in his book "The Science of Tennis," specific training, such as the forehand drive, can improve neuromuscular adaptations, increasing speed and agility. This training involves repetitive movements designed to strengthen the muscles used in the forehand stroke, improve coordination, and accelerate reaction time. All these factors collectively enhance an athlete's performance on the court (Dufresne, 2020). This study also aligns with the findings by Selmi et al., which state that intensive and focused training can significantly improve tennis players' physical parameters. The study emphasizes the importance of specially designed training to improve speed and agility (Selmi et al., 2024). Consistent and focused training enables players to develop specific skills relevant to tennis, such as quick changes in direction and rapid responses to incoming balls.

The training theory by Bompa and Haff in "Periodization: Theory and Methodology of Training" underscores the importance of periodization in a training program. Periodization is adjusting the intensity and volume of training to avoid overtraining and ensure athletes reach peak performance at the right time. In the context of this research, a well-designed training program over four weeks provided ample time for players to adapt and show significant improvement (Bompa & Haff, 2018). Well-structured and scheduled training allows players to maximize their physical potential gradually, reduce injury risks, and ensure optimal results. Moreover, this study confirms the theory put forward by Pluim et al, in "Health Benefits of Tennis," which states that regular tennis training enhances physical abilities and has long-term health benefits. Improved player speed and agility are crucial for on-court performance, cardiovascular health, and general fitness. Intensive tennis training can increase aerobic and anaerobic capacity, strengthening the heart and lungs and boosting overall metabolism (Pluim et al., 2007).

Furthermore, literature by Brown & Soulier in "Tennis: Steps to Success" indicates that forehand drive training enhances hand-eye coordination and stroke efficiency. This research supports the view that mastering basic techniques through repetitive practice improves game performance and reduces technical errors that can lead to injuries. In other words, players who regularly practice the forehand drive become faster and more agile, tactically and technically smarter on the court (Brown & Soulier, 2013). The results of this study are also supported by findings in "Biomechanics of Tennis" by Elliott, which show that training focused on the biomechanics of tennis movements can optimize movement efficiency and minimize wasted energy (Elliott, 2006). Repetitive forehand drive training helps players learn the most effective movement patterns, reduce muscle strain, and increase the accuracy and power of their shots. Thus, based on existing literature and this study's results, forehand drive training has significant benefits in improving tennis athletes' physical abilities and performance. The observed improvements in player speed and agility after the training program indicate that this method is effective and can be widely applied in tennis training programs.

In conclusion, the forehand drive training in this study can be used to train athletes' abilities in sports and serve as a foundation for further research. This research can contribute to a forehand training program for coaches to improve basic forehand techniques while enhancing the physical elements of speed and agility, which are crucial for a tennis athlete. The limitations of this study lie in the fact that there are still many training models that can be developed, but due to time constraints and other reasons, only this much could be done in this research. It is hoped that more varied and holistic models can be developed for future suggestions. The variety of training models can make athletes enthusiastic about training without feeling bored or tired. Updating training should be a consideration for researchers or coaches in developing basic techniques, physical conditions, tactics, and the mentality of a tennis athlete.

CONCLUSION

This study indicates that the forehand drive training model significantly improves the speed and agility of tennis players. The pre-test and post-test results show notable improvements in both variables, with the t-test values indicating statistical significance, thus proving the effectiveness of this training. The forehand drive training enhances neuromuscular adaptation, muscle strength, coordination, and reaction time, all of which contribute to improving on-court performance. This research also supports existing theories on the importance of focused and structured training in enhancing the physical abilities of tennis players. Moreover, it highlights the long-term health benefits of intensive tennis training, such as increased aerobic and anaerobic capacity, which positively impacts cardiovascular health and overall fitness. In addition to physical benefits, forehand drive training improves hand-eye coordination and stroke efficiency, reducing technical errors that can lead to injuries. Consequently, players become faster, more agile, and more tactically and technically adept on the court.

ACKNOWLEDGMENT

The article overviews how forehand drive training affects athletes' speed and agility. Thank you to the ATN tennis athletes who have carried out their training diligently so that they can complete this article.

AUTHOR CONTRIBUTION STATEMENT

R.J., A., K.F. Designed the research methodology and developed the forehand drive training model. Analyzed statistics and interpreted the results. Compiled the literature review and ensured theoretical relevance. N.M.A. Provided insights into the latest training methods and neuromuscular training strategies. A.S. Offered practical application perspectives in Burundi and contributed to data collection and validation.

REFERENCES

Abdioglu, M., Mor, H., & Mor, A. (2024). Field and court-based tests used in the determination of physical performance in tennis. *International Journal of Disabilities Sports and Health Sciences*, *7*(1), 245–260. https://doi.org/10.33438/ijdshs.1315076

Murphy, M. A., & Häger, C. K. (2015). Kinematic analysis of the upper extremity after stroke – how far have we reached and what have we grasped? *Physical Therapy Reviews*, *20*(3), 137–155. https://doi.org/10.1179/1743288X15Y.0000000002

Dewanti, R. A., Tarigan, B., & Budiana, D. (2018). Implementation of sport science coaching: improving strength and conditioning performance of tennis junior athletes. *Proceedings of the 2nd Yogyakarta International Seminar on Health, Physical Education, and Sport Science (YISHPESS 2018) and 1st Conference on Interdisciplinary Approach in Sports (CoIS 2018)*. https://doi.org/10.2991/yishpess-cois-18.2018.146

Bahamonde, R. E., & Knudson, D. (2003). Kinetics of the upper extremity in the open and square stance tennis forehand. *Journal of Science and Medicine in Sport*, *6*(1), 88–101. https://doi.org/10.1016/S1440-2440(03)80012-9

Bompa, T. O., & Haff, G. G. (2018). *Periodization: Theory and methodology of training*. Human Kinetics.

https://books.google.co.id/books?id=pu96DwAAQBAJ. https://doi.org/10.5040/9781718225435
Brown, J., & Soulier, C. (2013). *Tennis: Steps to success*. Human Kinetics. https://books.google.co.id/books?id=ZN8Ou4UfPtsC
Chao, H.-H., Liao, Y.-H., & Chou, C.-C. (2021). Influences of recreational tennis-playing exercise time on cardiometabolic health parameters in healthy elderly: The ExAMIN AGE study. *International Journal of Environmental Research and Public Health*, *18*(3), 1255. https://doi.org/10.3390/ijerph18031255
Creswell, J. W. (2010). *Research design: Qualitative, quantitative, and mixed approach*. PT. Pustaka Pelajar.
Delgado-García, G., Vanrenterghem, J., Muñoz-García, A., Ruiz-Malagón, E. J., Mañas-Bastidas, A., & Soto-Hermoso, V. M. (2019). Probabilistic structure of errors in forehand and backhand groundstrokes of advanced tennis players. *International Journal of Performance Analysis in Sport*, *19*(5), 698–710. https://doi.org/10.1080/24748668.2019.1647733
Deng, N., Soh, K. G., Abdullah, B., Huang, D., Sun, H., & Xiao, W. (2023). Effects of physical training programs on female tennis players' performance: a systematic review and meta-analysis. *Frontiers in Physiology*, *14*. https://doi.org/10.3389/fphys.2023.1234114
Domínguez, R., Sánchez Oliver, A. J., Fernandes da Silva, S., López-Samanes, A., Martínez-Sanz, J. M., & Mata, F. (2021). Dietary-nutritional needs in tennis: A narrative review. *Revista Española de Nutrición Humana y Dietética*, *25*, e1029. https://doi.org/10.14306/renhyd.25.S1.1029
Dufresne, E. (2020). *The science of tennis*. Greenhaven Publishing LLC. https://books.google.co.id/books?id=2oReEAAAQBAJ
Elliott, B. (2006). Biomechanics and tennis. *British Journal of Sports Medicine*, *40*(5), 392–396. https://doi.org/10.1136/bjsm.2005.023150
Elliott, B., Marsh, T., & Overheu, P. (1989). A biomechanical comparison of the multisegment and single unit topspin forehand drives in tennis. *International Journal of Sport Biomechanics*, *5*(3), 350–364. https://doi.org/10.1123/ijsb.5.3.350
Ferrauti, A., Ulbricht, A., & Fernandez-Fernandez, J. (2018). Assessment of physical performance for individualized training prescription in tennis. in *tennis medicine* (pp. 167–188). Springer International Publishing. https://doi.org/10.1007/978-3-319-71498-1_12
Fleming, J., Naughton, R., & Harper, L. (2018). Investigating the nutritional and recovery habits of tennis players. *Nutrients*, *10*(4), 443. https://doi.org/10.3390/nu10040443
Genevois, C. (2019). The importance of aerobic fitness for tennis: A review (part 1). *ITF Coaching & Sport Science Review*, *27*(79), 20–22. https://doi.org/10.52383/itfcoaching.v27i79.79
Genevois, C., Reid, M., Creveaux, T., & Rogowski, I. (2020). Kinematic differences in upper limb joints between flat and topspin forehand drives in competitive male tennis players. *Sports Biomechanics*, *19*(2), 212–226. https://doi.org/10.1080/14763141.2018.1461915
Girard, O., & Millet, G. P. (2009). Physical Determinants of tennis performance in competitive teenage players. *Journal of Strength and Conditioning Research*, *23*(6), 1867–1872. https://doi.org/10.1519/JSC.0b013e3181b3df89
Gomes, R. V., Capitani, C. D., Ugrinowitsch, C., Zourdos, M. C., Fernandez-Fernandez, J., Mendez-Villanueva, A., & Aoki, M. S. (2013). Does carbohydrate supplementation enhance tennis match play performance? *Journal of the International Society of Sports Nutrition*, *10*(1), 1–7. https://doi.org/10.1186/1550-2783-10-46
Granacher, U., & Borde, R. (2017). Effects of sport-specific training during the early stages of long-term athlete development on physical fitness, body composition, cognitive, and academic performances. *Frontiers in Physiology*, *8*. https://doi.org/10.3389/fphys.2017.00810
Gueugneau, N., Pozzo, T., Darlot, C., & Papaxanthis, C. (2017). Daily modulation of the speed–accuracy trade-off. *Neuroscience*, *356*, 142–150. https://doi.org/10.1016/j.neuroscience.2017.04.043
Jackson, M. J., Roche, D. M., Amirabdollahian, F., Koehn, S., & Khaiyat, O. A. (2020). The musculoskeletal health benefits of tennis. *Sports Health: A Multidisciplinary Approach*, *12*(1), 80–87. https://doi.org/10.1177/1941738119880862
Kolman, N. S., Kramer, T., Elferink-Gemser, M. T., Huijgen, B. C. H., & Visscher, C. (2019). Technical and tactical skills related to performance levels in tennis: A systematic review. *Journal of Sports Sciences*, *37*(1), 108–121. https://doi.org/10.1080/02640414.2018.1483699

Landlinger, J., Lindinger, S. J., Stöggl, T., Wagner, H., & Müller, E. (2010). Kinematic differences of elite and high-performance tennis players in the cross court and down the line forehand. *Sports Biomechanics*, *9*(4), 280–295. https://doi.org/10.1080/14763141.2010.535841

Lorenz, D. S., Reiman, M. P., Lehecka, B. J., & Naylor, A. (2013). What performance characteristics determine elite versus nonelite athletes in the same sport? *Sports Health: A Multidisciplinary Approach*, *5*(6), 542–547. https://doi.org/10.1177/1941738113479763

Lanzoni, I. M., Bartolomei, S., Di Michele, R., & Fantozzi, S. (2018). A kinematic comparison between long-line and cross-court top spin forehand in competitive table tennis players. *Journal of Sports Sciences*, *36*(23), 2637–2643. https://doi.org/10.1080/02640414.2018.1456394

Martin-Lorente, E., Campos, J., & Crespo, M. (2017). The inside out forehand as a tactical pattern in men's professional tennis. *International Journal of Performance Analysis in Sport*, *17*(4), 429–441. https://doi.org/10.1080/24748668.2017.1349528

Michel, M.-F., Girard, O., Guillard, V., & Brechbuhl, C. (2023). Well-being as a performance pillar: A holistic approach for monitoring tennis players. *Frontiers in Sports and Active Living*, *5*. https://doi.org/10.3389/fspor.2023.1259821

Munivrana, G., Furjan-Mandić, G., & Kondrič, M. (2015). Determining the structure and evaluating the role of technical-tactical elements in basic table tennis playing systems. *International Journal of Sports Science & Coaching*, *10*(1), 111–132. https://doi.org/10.1260/1747-9541.10.1.111

Navia, J. A., Avilés, C., Dicks, M., & Ruiz-Pérez, L. M. (2022). The spatiotemporal control of expert tennis players when returning first serves: A perception-action perspective. *Journal of Sports Sciences*, *40*(1), 16–23. https://doi.org/10.1080/02640414.2021.1976484

Ohguni, M., Aoki, M., Sato, H., Imada, K., & Funane, S. (2009). The effect of grip size on the hitting force during a soft tennis forehand stroke. *Sports Health: A Multidisciplinary Approach*, *1*(4), 321–325. https://doi.org/10.1177/1941738109338547

Pluim, B. M., Staal, J. B., Marks, B. L., Miller, S., & Miley, D. (2007). Health benefits of tennis. *British Journal of Sports Medicine*, *41*(11), 760–768. https://doi.org/10.1136/bjsm.2006.034967

Pol, R., Balagué, N., Ric, A., Torrents, C., Kiely, J., & Hristovski, R. (2020). Training or synergizing? Complex systems principles change the understanding of sport processes. *Sports Medicine - Open*, *6*(1), 28. https://doi.org/10.1186/s40798-020-00256-9

Rana, M., & Mittal, V. (2021). Wearable sensors for real-time kinematics analysis in sports: A review. *IEEE Sensors Journal*, *21*(2), 1187–1207. https://doi.org/10.1109/JSEN.2020.3019016

Reid, M., Crespo, M., Lay, B., & Berry, J. (2007). Skill acquisition in tennis: Research and current practice. *Journal of Science and Medicine in Sport*, *10*(1), 1–10. https://doi.org/10.1016/j.jsams.2006.05.011

Reid, M., & Schneiker, K. (2008). Strength and conditioning in tennis: Current research and practice. *Journal of Science and Medicine in Sport*, *11*(3), 248–256. https://doi.org/10.1016/j.jsams.2007.05.002

Roetert, E. P., Ellenbecker, T. S., & Reid, M. (2009). Biomechanics of the tennis serve: Implications for strength training. *Strength & Conditioning Journal*, *31*(4), 35–40. https://doi.org/10.1519/SSC.0b013e3181af65e1

Roetert, E. P., Garrett, G. E., Brown, S. W., & Camaione, D. N. (1992). Performance profiles of nationally ranked junior tennis players. *Journal of Strength and Conditioning Research*, *6*(4), 225–231. https://doi.org/10.1519/00124278-199211000-00006

Russell, M., & Kingsley, M. (2014). The efficacy of acute nutritional interventions on soccer skill performance. *Sports Medicine*, *44*(7), 957–970. https://doi.org/10.1007/s40279-014-0184-8

Rutherford, J. (2017). *Skills, drills & strategies for tennis*. Routledge. https://doi.org/10.4324/9781315213002

Mencia, E. S., Campos-Rius, J., González Santamaría, X., & Borrajo Mena, E. (2024). Tactical skills in tennis: A systematic review. *International Journal of Sports Science & Coaching*, *19*(2), 894–907. https://doi.org/10.1177/17479541231216268

Seeley, M. K., Funk, M. D., Denning, W. M., Hager, R. L., & Hopkins, J. T. (2011). Tennis forehand kinematics change as post-impact ball speed is altered. *Sports Biomechanics*, *10*(4), 415–426. https://doi.org/10.1080/14763141.2011.629305

Selmi, W., Hammami, A., Hammami, R., Ceylan, H. İ., Morgans, R., & Simenko, J. (2024). Effects of a 6-week agility training program on emotional intelligence and attention levels in adolescent

tennis players. *Applied Sciences*, *14*(3), 1070. https://doi.org/10.3390/app14031070
Siekańska, M., Bondár, R. Z., di Fronso, S., Blecharz, J., & Bertollo, M. (2021). Integrating technology in psychological skills training for performance optimization in elite athletes: A systematic review. *Psychology of Sport and Exercise*, *57*, 102008. https://doi.org/10.1016/j.psychsport.2021.102008
Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). Position of the academy of nutrition and dietetics, dietitians of Canada, and the American college of sports medicine: Nutrition and Athletic Performance. *Journal of the Academy of Nutrition and Dietetics*, *116*(3), 501–528. https://doi.org/10.1016/j.jand.2015.12.006
Ulbricht, A., Fernandez-Fernandez, J., Mendez-Villanueva, A., & Ferrauti, A. (2016). Impact of fitness characteristics on tennis performance in elite junior tennis players. *Journal of Strength and Conditioning Research*, *30*(4), 989–998. https://doi.org/10.1519/JSC.0000000000001267
Unierzyski, P. G., & Crespo, M. (2008). Modern teaching methods for tennis: What do they have in common? In *Science and Racket Sports IV* (pp. 291–296). Routledge.
Wormhoudt, R., Savelsbergh, G. J. P., Teunissen, J. W., & Davids, K. (2017). *The Athletic Skills Model*. Routledge. https://doi.org/10.4324/9781315201474
Zaferanieh, A., Haghighi, A. H., Kakhak, S. A. H., Maleki, A., Cè, E., & Esposito, F. (2021). Effect of ballistic and power training on performance adaptations of élite table tennis players. *Sport Sciences for Health*, *17*(1), 181–190. https://doi.org/10.1007/s11332-020-00671-1