

Effect of sports experiences on competition level and exercise habits in Japanese collegiate athletes

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ABSTRACT

In this study, we investigated the athletic experiences of former collegiate Japanese athletes and compared their competitive results and current exercise habits. A questionnaire survey was completed by physical education or health and sports science students via mail. We sent the survey to 9,507 people; 2,141 questionnaires were returned, accounting for a recovery rate of 22.5%. We collected data on the current level of physical activity, history of sports experiences, and type of athletic competitions participated in from childhood until adulthood. An analysis was conducted on 1,999 participants. The results suggested that Japanese collegiate athletes had continued the same sport since elementary school. Conversely, several recent athletes had multiple-sport experiences and had started sports from an early age. There were no differences in athletic history and athletic performance between some age groups. We believe that having experience in a variety of sports has no adverse effect on athletic performance or exercise habits. In conclusion, compared to the past, the number of collegiate athletes with multiple experiences has increased. However, their experience differed from multiple-sport environments observed outside Japan. It is necessary to reconsider the sports environment of Japanese children in the future.

Keywords: Physical education, Athletic experience, Athletic performance, Multiple-sport experience, Single sport, Young athlete.

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INTRODUCTION

Many athletes specialize in a single sport since childhood, and parents and coaches have a strong influence on the early specialization of athletes (Anderson et al., 2020). This trend is common among the participants in artistic sports competitions in many countries, such as artistic gymnastics and figure skating (Ericsson et al., 1993; Güllich and Emrich, 2014; Myer et al., 2015). A previous study indicated that becoming proficient in chess requires more than 10,000 hours of practice (Simon and Chase, 1973). Moreover, Macnamara and Maitra reported practice times according to the skill level of violinists (Macnamara and Maitra, 2019). This trend is seen in athletics as well, and the 10-year rule, wherein it is believed that an athlete must be involved in their activity for a minimum of 10 years before being able to compete internationally, has been validated in previous research (Baker, 2003; Caruso, 2013). Furthermore, individuals aiming for competitions must begin specific long-term training as early as possible, with various approaches being tested for discovering talents at an early age (Rees et al., 2016). However, playing a variety of sports and attaining mental and physical maturity before choosing an activity that suits the individual may improve the likelihood of achieving high levels of sporting performance (Bridge and Toms, 2013).

Recently, it has been reported that traditional talent discovery and development programs do not necessarily produce favourable results. Vaeyens et al. (2009) described the experience of injuries, burnout, and other consequences as demerits of early specialization. Additionally, the International Olympic Committee has released a position statement on the development of young athletes (Bergeron et al., 2015), and the National Strength and Conditioning Association and the American Medical Society for Sports Medicine have also made statements related to long-term athletic development, overuse injuries, and burnout (DiFiori et al., 2014; Lloyd et al., 2016). Furthermore, the harmful effects and dangers of single-sport specialization are being increasingly emphasized in some recent reports (Jayanthi et al., 2019). It has been shown that from a personal-health perspective, specialized training and rigorous practice from an early age can increase the risk of injuries. Notably, several athletes have discontinued sports owing to issues such as burnout and injury. However, the fact that many young people and athletes still face these issues requires attention.

Regarding exercise and health, engaging in rigorous competitive sports during adolescence does not guarantee improved health thereafter. For example, it was reported that a group of former university athletes had lower levels of physical fitness than that of non-athletes (Simon and Docherty, 2017). As it is well-established that exercise has a positive effect on health (Grøntved et al., 2014; Hernelahti et al., 2002), maintaining exercise habits into adulthood would be optimal. Owing to the strong influence of rigorous exercise specific to certain sports, athletes who continue to pursue their sport up to the college level may not acquire the exercise habits necessary for maintaining good health. By studying individuals with athletic backgrounds at the college level, we may obtain clearer insights into the current prevalent sporting environment and explore long-term changes in individuals with this history.

With the established literature, it is difficult to compare the benefits of long-term specialized training in a single sport from childhood to improve an athlete's competitive skills and exposure to a variety of sports for improving mental and physical health, and there is little objective evidence to clearly suggest that either is better. Traditionally, the idea of multiple sports and season sports is not common in Japanese physical education. Moreover, physical education and sports were primarily meant for physical education and club activities at school. However, sports training that emphasizes winning for mentally or emotionally immature school children has caused several problems in Japan. Some previous studies have reported on the characteristics of the National Collegiate Athletic Association (NCAA) college athletes' sports careers (Martin

et al., 2017; Swindell et al., 2019). As an example, Martin et al. (2017) reported that NCAA college athletes played three or more sports, with children 12.5 years old typically specializing in one sport.

Therefore, the present study aimed to compare the athletic experiences of Japanese college athletes based on historical data by age group and to elucidate the relationship between athletic experience and athletic performance. To this end, we classified the athletic experiences and performance of participants in childhood and adolescence while taking into consideration the prevalent sporting environment in Japan. We also examined the differences in characteristics between age groups. Additionally, we focused on whether or not the subjects presently engage in regular exercise to determine if former college athletes continue to exercise.

METHODS

Participants

The participants had similar educational backgrounds, majored in physical education or health and sports science, and most of them engaged in competitive sports during college. The participants were ex-students who had graduated between 1956 and 2018. We sent the survey to 9,507 people; 2,141 questionnaires were returned, accounting for a recovery rate of 22.5%. Of the 2,141 total received questionnaires, 1,794 were from male respondents, and 347 were from female respondents. Of the respondents, 1,999 participants who answered our study questions related to sports played, competition level, exercise habits, etc., were included in the analysis. The participants returned the questionnaire if they consented to participate in this survey. This study was conducted in accordance with the principles embodied in the Declaration of Helsinki and was approved by the Research Ethics Committee of the Faculty of Health and Sports Science, Juntendo University (approval no. 2021-28).

Measures

Survey questions inquired about participants' basic attributes and current physical activities. We investigated whether the participants performed vigorous or moderate physical activity or walked with reference to the International Physical Activity Questionnaire (IPAQ) (Kawashima et al., 2014; Murase et al., 2002). We also collected data on the day of the week and the time of day of these activities. To gain insights into the athletic history of the participants, we collected information on any sports club involvement during their time at the university. Additionally, we sought information on the kinds of competitive sports that respondents participated in as athletes from childhood till the present day. Specifically, we investigated the sport, the duration of participation at the highest level of competition, and the age at which they participated. Those with a single-sport experience were grouped into the single-experience (SE) group, and those with experience in two or three sports were grouped into the multiple-experience (ME) group.

Procedures

This study was conducted as part of the J-Fit+ Study. A questionnaire survey was conducted among the participants from the Faculty of Physical Education or Health and Sports Science of Juntendo University as part of alumni research via mail. The main questions regarding this study were conducted as a retrospective survey, and participants returned questionnaires.

Analysis

In this study, we primarily showed the ratio by sex and age. In the analysis related to competition results, the results at the university level were used as the standard. However, when the competition results at the high school level were higher than the competition results at the university level (or they had no experience as athletes at the university level), the analysis target was high school results. For exercise habits, the amount

of activity was investigated and calculated with reference to the IPAQ (Kawashima et al., 2014; Murase et al., 2002). For the data on exercise habits, the IPAQ target age of 69 years or younger was adopted. In this study, IPAQ formulas were used to identify participants with exercise habits of 600 metabolic equivalents (MET)-minutes per week or more. The MET-minutes per week were calculated as follows: walking = 3.3 METs; moderate-intensity activity = 4.0 METs; and vigorous-intensity activity = 8.0 METs. A chi-square test was performed on the relationship between competition results and sports experience by age and sex. A similar analysis was also performed on the relationship between exercise habits and sports experience. The significance level was set at $p < .05$.

RESULTS

The mean age of the participants was 51.3 ± 16.5 years (54.6 ± 15.5 years for males and 33.4 ± 7.3 years for females). Regarding the number of sports experienced, 1,165 (58.3%) experienced one sport, 567 (28.4%) experienced two sports, and 267 (13.4%) experienced three sports. This survey made provision for a maximum of three sports experiences.

Figure 1 shows the percentage of sports experiences by sex and age. Among men, 1,024 (60.6%) belonged to the SE group, whereas 667 (39.4%) were in the ME group. Among women, 141 (45.8%) belonged to the SE group, whereas 167 (54.2%) were in the ME group.

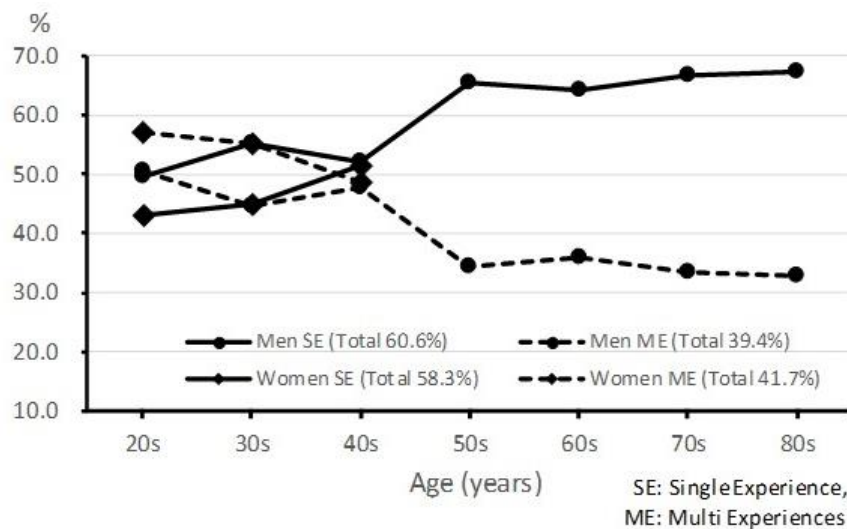


Figure 1. Percentage of sports experiences grouped by sex and age.

Table 1 shows the sports experience and competition level by sex and age. Among men in the SE group, more than half competed at the national tournament level or higher. Among men in the ME group, there was some variation depending on age; however, about half competed at the national tournament level, whereas the other half competed at other levels. Significant results were shown by the chi-square test for participants aged 20–29 and 60–69 years, as well as for the total respondents. Among women in the SE group, a high proportion of those aged 40–49 years competed at the prefectural/local tournament level, whereas the proportion of those aged 20–29 years at the national tournament level was high.

Table 2 shows the sports experiences and current exercise habits by sex and age. No significant results were obtained by the chi-square test.

Table 1. Sports experiences and competition levels according to sex and age.

Sex	Age range	Single-experience group					Multiple-experience group					χ^2
		National tournament level or higher		Prefectural or local tournament level		Total	National tournament level or higher		Prefectural or local tournament level		Total	
		n	%	n	%		n	%	n	%		
Men	20s	30	54.5	25	45.5	55	43	76.8	13	23.2	56	$p < .05$
	30s	47	55.3	38	44.7	85	36	44.4	45	55.6	81	
	40s	66	50.0	66	50.0	132	53	40.5	78	59.5	131	
	50s	114	68.3	53	31.7	167	54	56.3	42	43.8	96	$p < .05$
	60s	134	62.6	80	37.4	214	61	49.2	63	50.8	124	
	70s	85	57.0	64	43.0	149	35	50.0	35	50.0	70	
	80s	17	51.5	16	48.5	33	5	29.4	12	70.6	17	$p < .05$
	Total	493	59.0	342	41.0	835	287	49.9	288	50.1	575	
Women	20s	28	60.9	18	39.1	46	27	45.8	32	54.2	59	
	30s	19	50.0	19	50.0	38	29	48.3	31	51.7	60	
	40s	12	38.7	19	61.3	31	15	40.5	22	59.5	37	
	Total	59	51.3	56	48.7	115	71	45.5	85	54.5	156	

Table 2. Sports experience and current exercise habits according to sex and age.

Sex	Age range	Single-experience group					Multiple-experience group				
		None		Regular exercise		Total	None		Regular exercise		Total
		n	%	n	%		n	%	n	%	n
Men	20s	9	14.1	55	85.9	64	3	4.6	62	95.4	65
	30s	24	20.9	91	79.1	115	13	14.0	80	86.0	93
	40s	44	27.8	114	72.2	158	44	30.3	101	69.7	145
	50s	66	31.3	145	68.7	211	26	23.4	85	76.6	111
	60s	72	28.1	184	71.9	256	41	28.7	102	71.3	143
	Total	215	26.7	589	73.3	804	127	22.8	430	77.2	557
Women	20s	7	14.3	42	85.7	49	17	26.2	48	73.8	65
	30s	15	28.3	38	71.7	53	19	29.2	46	70.8	65
	40s	18	46.2	21	53.8	39	13	35.1	24	64.9	37
	Total	40	28.4	101	71.6	141	49	29.3	118	70.7	167

Figure 2 shows the age at the start of competitive sports participation by sex and age. The younger study participants were younger when they started playing competitive sports than the older study participants. In addition, those in the ME group were younger when they started competitive sports. Table 3 shows the starting ages for typical sports among men in the SE group. Younger participants had a lower starting age for all sports, with soccer, baseball, and artistic gymnastics having the youngest starting ages.

Women in the SE group started playing soccer at the age of 8.17 years ($n = 6$), basketball at the age of 10.48 years ($n = 33$), volleyball at the age of 11.00 years ($n = 23$), and track and field at the age of 12.03 years ($n = 38$).

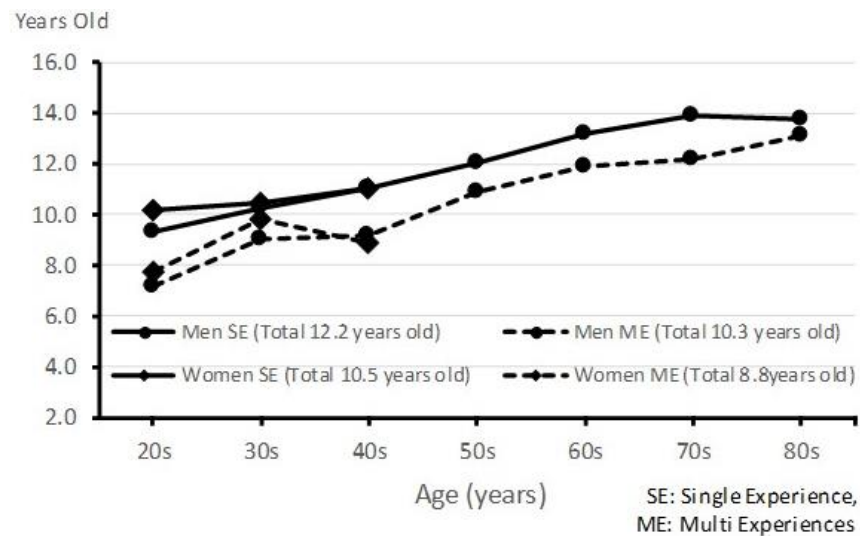


Figure 2. Age at the start of competitive sports participation by sex and age.

Table 3. Age ranges (decades) and average age at the start of sports participation (years) among men in the single-experience group.

Age range	Track and field		Soccer		Basketball		Baseball		Gymnastics		Volleyball	
	n	Age	n	Age	n	Age	n	Age	n	Age	n	Age
20s	13	12.23	9	7.67	7	10.29	15	8.33	4	5.75	4	11.75
30s	22	11.91	24	8.33	10	11.40	22	10.18	7	6.86	6	12.50
40s	52	12.94	32	9.38	10	12.50	24	9.46	7	9.14	10	12.20
50s	60	13.40	36	10.72	30	12.60	17	10.76	12	12.33	18	13.11
60s	102	13.46	20	13.10	29	13.62	8	12.25	28	12.71	30	13.50
70s	81	13.89	11	14.36	14	13.93	1		31	14.06	16	13.63
80s	11	14.09	4	13.75	1		8	12.13	3	14.33	7	14.86
Total	341	13.35	136	10.51	101	12.82	95	10.18	92	12.15	91	13.26

DISCUSSION

The difference between specializing in a single sport over a long time period since childhood and experiencing multiple sports is unknown. In the present study, we retrospectively investigated and compared the sporting performance of participants based on acquired data regarding their sports participation history. Our results suggested that 1) more than half of Japanese collegiate athletes experienced a single sport; 2) the number of athletes with multiple-sport experiences is increasing, and the age of starting sports is decreasing; and 3) multiple-sport experiences do not adversely affect athletic performance or exercise habits in later years.

Although there have been movements in recent years emphasizing a variety of sports and exercises for the youth, there is a paucity of objective evidence supporting this recommendation. Sport club activities in school are a part of the Japanese physical education curriculum, and despite being extracurricular in nature, such engagements are led by the school teaching staff, and students undertake sporting activities during school hours and on the school premises. However, participating in multiple sports is not widespread in Japan.

Our results suggested that more than 60% of past college athletes aged 50 years and older had a single-sport experience only and that, over recent years, 50% of college athletes had been exposed to multiple athletic experiences. In the younger generation, the proportion of people who have multiple-sport experiences is increasing. It is conceivable that in the last 20 years, sports environments have been created for professional engagement in sports from an early age. In addition, it is commonly considered that those who play a single sport reach a slightly higher competition level (national tournament level or higher). In this study, the competition level of those in the ME group varied slightly depending on age; therefore, we cannot draw any clear conclusions. However, it is possible to attain a certain level of competition even if an athlete has had multiple-sport experiences. In the ME group, the proportion of study participants aged 20–29 years who performed above the national tournament level was significant.

Many previous studies have reported favourable outcomes associated with multiple-sport experiences at an early stage followed by specialization at a later stage (Buckley et al., 2020; Myer et al., 2016). In particular, there are many studies on late specialization in measurement-related sports (Moesch et al., 2011; Solberg et al., 2019). However, many athletes specialize in sports at an early age, and this trend appears to be a consequence of the strict institutionalization of various organizations, associations, and competitions. Moreover, there has been a tendency for people in Japan to engage in a single sport since childhood, and a great deal of media coverage and general popularity surrounds famous athletes who emerge from such practices. Considering the current Japanese sports environment and the perspective of parents and guardians, there is concern that opportunities to experience various sports will not increase in the future. This study suggests that athletic performance does not depend on early specialization in a sport or on multiple-sport experiences. Early specialization and long-term development, accompanied by vigilance for injuries and burnout, should be encouraged. Additionally, in the future, we can expect the further promotion of multiple-sport experiences and an increase in athletes who compete at the highest level in multiple sports. This will require more detailed research specific to each type of sport.

The relationship between sports experience and exercise habits was also analysed in this study. It is clear that exercise has a positive effect on health (Bell et al., 2019; Grøntved et al., 2014; Hernelahti et al., 2002), and several health studies on former elite athletes have been conducted (Moseid et al., 2019; Zwiers et al., 2012). The effect of past exercise and sports experience on the acquisition of exercise habits has been studied (Itoh et al., 2017); however, the exercise habits of former athletes have not been analysed in detail (Sorenson et al., 2015). According to the results of this study, many participants performed a certain amount of exercise, and it can be inferred that there is no difference in exercise habits due to differences in sports experience. However, among the youth, people with multiple-sport experiences were shown to engage in exercise regularly, validating concerns that individuals who practiced a single sport for a long time end up with low levels of exercise after finishing the active competition. It may be advantageous to have experience in multiple sports to acquire exercise habits; however, future verification of this theory is necessary. In addition to coached sports, it will be important to evaluate the importance of acquiring future exercise habits. An athlete's health is an important aspect that should be factored in when analysing the athletic experience.

Finally, we aggregated results regarding the starting age for competitive participation. Swindell et al. (2019) reported that 94.7% of NCAA athletes experienced multiple sports. In the current study, more than half of the participants had a single-sport experience, which differs from the general experience in the United States. Historically, a large number of participants had a single-sport experience only; however, the age at which competition sports starts was late. Possibly, these athletes were experiencing sports at play or leisure in their daily lives. In recent years, the sports environment of children has changed, and it is clear that children start engaging in sports at an early age. Although the number of people with multiple-sport experiences has

increased, cases of multiple competition experiences in Japan are limited. Recently, whether or not to uphold national conventions on childhood well-being has become controversial, as children face a scarcity of space and time to be able to play sports and exercise casually, and these conventions are based on playing club sports.

Specifically, research in track and field athletics indicated that it may not always be necessary to specialize at an early stage (Boccia et al., 2019; Boccia et al., 2021a; Boccia et al., 2021b; Haugen et al., 2018). Our data suggested that Japanese college athletes generally limit the sport that they specialize in early and that college athletes with only a single-sport experience in this study were particularly young at the start of baseball, gymnastics, and soccer. Many children have been playing soccer or baseball, which are popular sports in Japan since they were young. Martin et al. (2017) reported the age at which NCAA college athletes specialized, showing that those specializing in baseball were aged 15.4 years on average, whereas soccer players were aged 11.3 years on average. Additionally, in both the NCAA and Japan, artistic gymnastics athletes specialize early. Moreover, as in soccer, the rapid decline in age over recent years is a major feature.

Outside Japan, it is not rare to see cases in which individuals experience a variety of sports and exercises beginning in childhood and continue to specialize in multiple sports after a certain age. In Japan, however, research on sports experience and talent transfer is scarce. The sporting environment of children in Japan is thought to be influenced by the way of thinking of coaches and parents in recent years. Future surveys of a large number of participants in each sport are needed to provide detailed findings. Studies are also reporting in detail the career patterns of athletes (Gulbin et al., 2013). The careers of female athletes are increasingly being examined (DiCesare et al., 2019; Malina, 2010; Post et al., 2017); however, further research on women in sports is necessary. Although there were some limits to our research, the results of this study were significant in that they clarified the historical characteristics and recent trends of the sports careers of Japanese college athletes. The sports experiences of athletes with high abilities at the college level and the same educational background were clarified.

CONCLUSIONS

This study reported the historical sports experiences of collegiate athletes by age group, showing that more than half of Japanese college athletes experienced only one sport. However, compared with the past, the number of athletes with multiple-sport experiences is increasing, and children are commencing sports at a relatively young age. Moreover, multiple-sport experiences do not appear to adversely affect athletic performance and exercise habits in later life. Our results could lead to safer and more effective measures for improving the competitive environment in youth sports and form a basis for the lifelong enjoyment of sports.

AUTHOR CONTRIBUTIONS

All authors designed the study. Data collection, Y. K., K. S., Y. S., and K. A.; analysis and interpretation, Y. K., and Y. S.; drafting and revision, Y. K., and K. S. All authors agreed to the published version of the manuscript.

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DISCLOSURE STATEMENT

No potential conflict of interest were reported by the authors.

REFERENCES

- Anderson, F.L., Knudsen, M.L., Ahmad, C.S., & Popkin, C.A. (2020). Current trends and impact of early sports specialization in the throwing athlete. *Orthop Clin North Am*, 51(4), 517-525. <https://doi.org/10.1016/j.ocl.2020.06.006>
- Baker, J. (2003). Early specialization in youth sport: A requirement for adult expertise? *High Abil Stud*, 14(1), 85-94. <https://doi.org/10.1080/13032000093526>
- Bell, D.R., DiStefano, L., Pandya, N.K., & McGuine, T.A. (2019). The public health consequences of sport specialization. *J Athl Train*, 54(10), 1013-1020. <https://doi.org/10.4085/1062-6050-521-18>
- Bergeron, M.F., Mountjoy, M., Armstrong, N., Chia, M., Côté, J., Emery, C.A., ... & Engebretsen, L. (2015). International Olympic Committee consensus statement on youth athletic development. *Br J Sports Med*, 49(13), 843-851. <https://doi.org/10.1136/bjsports-2015-094962>
- Boccia, G., Brustio, P.R., Moisé, P., Franceschi, A., La Torre, A., Schena, F., ... & Cardinale, M. (2019). Elite national athletes reach their peak performance later than non-elite in sprints and throwing events. *J Sci Med Sport*, 22(3), 342-347. <https://doi.org/10.1016/j.jsams.2018.08.011>
- Boccia, G., Cardinale, M., & Brustio, P.R. (2021a). Performance progression of elite jumpers: Early performances do not predict later success. *Scand J Med Sci Sports*, 31(1), 132-139. <https://doi.org/10.1111/sms.13819>
- Boccia, G., Cardinale, M., & Brustio, P.R. (2021b). World-class sprinters' careers: Early success does not guarantee success at adult age. *Int J Sports Physiol Perform*, 16(3), 367-374. <https://doi.org/10.1123/ijsp.2020-0090>
- Bridge, M.W., & Toms, M.R. (2013). The specialising or sampling debate: A retrospective analysis of adolescent sports participation in the UK. *J Sports Sci*, 31(1), 87-96. <https://doi.org/10.1080/02640414.2012.721560>
- Buckley, P.S., Ciccotti, M.C., Bishop, M., Kane, P., Selverian, S., Exume, D., ... & Ciccotti, M.G. (2020). Youth single-sport specialization in professional baseball players. *Orthop J Sports Med*, 8(3), 2325967120907875. <https://doi.org/10.1177/2325967120907875>
- Caruso, T. (2013). Early sport specialization versus diversification in youth athletes. *NSCA Coach*, 2, 22-25. Retrieved from: <https://www.nsca.com/education/articles/nsca-coach/early-sport-specialization-versus-diversification-in-youth-athletes/>
- DiCesare, C.A., Montalvo, A., Foss, K.D.B., Thomas, S.M., Hewett, T.E., Jayanthi, N.A., & Myer, G.D. (2019). Sport specialization and coordination differences in multisport adolescent female basketball, soccer, and volleyball athletes. *J Athl Train*, 54(10), 1105-1114. <https://doi.org/10.4085/1062-6050-407-18>
- DiFiori, J.P., Benjamin, H.J., Brenner, J., Gregory, A., Jayanthi, N., Landry, G.L., & Luke, A. (2014). Overuse injuries and burnout in youth sports: A position statement from the American Medical Society for Sports Medicine. *Clin J Sport Med*, 24(1), 3-20. <https://doi.org/10.1097/JSM.0000000000000060>
- Ericsson, K.A., Krampe, R.T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychol Rev*, 100, 363-406. <https://doi.org/10.1098/rsos.190327>
- Grøntved, A., Pan, A., Mekary, R.A., Stampfer, M., Willett, W.C., Manson, J.E., & Hu, F.B. (2014). Muscle-strengthening and conditioning activities and risk of type 2 diabetes: A prospective study in

- two cohorts of US women. *PLoS Med*, 11(1), e1001587. <https://doi.org/10.1371/journal.pmed.1001587>
- Gulbin, J., Weissensteiner, J., Oldenzel, K., & Gagné, F. (2013). Patterns of performance development in elite athletes. *Eur J Sport Sci*, 13(6), 605-614. <https://doi.org/10.1080/17461391.2012.756542>
- Güllich, A., & Emrich, E. (2014). Considering long-term sustainability in the development of world class success. *Eur J Sport Sci*, 14 Suppl 1, S383-S397. <https://doi.org/10.1080/17461391.2012.706320>
- Haugen, T.A., Solberg, P.A., Foster, C., Morán-Navarro, R., Breitschädel, F., & Hopkins, W.G. (2018). Peak age and performance progression in world-class track-and-field athletes. *Int J Sports Physiol*, 13(9), 1122-1129. <https://doi.org/10.1123/ijsp.2017-0682>
- Hernelahti, M., Kujala, U.M., Kaprio, J., & Sarna, S. (2002). Long-term vigorous training in young adulthood and later physical activity as predictors of hypertension in middle-aged and older men. *Int J Sports Physiol*, 23(3), 178-182. <https://doi.org/10.1055/s-2002-23176>
- Itoh, H., Kitamura, F., Hagi, N., Mashiko, T., Matsukawa, T., & Yokoyama, K. (2017). Leisure-time physical activity in youth as a predictor of adult leisure physical activity among Japanese workers: A cross-sectional study. *Environ Health Prev Med* 22(1), 37. <https://doi.org/10.1186/s12199-017-0648-1>
- Jayanthi, N.A., Post, E.G., Laury, T.C., & Fabricant, P.D. (2019). Health consequences of youth sport specialization. *J Athl Train*, 54(10), 1040-1049. <https://doi.org/10.4085/1062-6050-380-18>
- Kawashima, M., Uchino, M., Yokoi, N., Uchino, Y., Dogru, M., Komuro, A., ... & Tsubota, K. (2014). The association between dry eye disease and physical activity as well as sedentary behavior: Results from the Osaka Study. *J Ophthalmol*, 2014, 943786. <https://doi.org/10.1155/2014/943786>
- Lloyd, R.S., Cronin, J.B., Faigenbaum, A.D., Haff, G.G., Howard, R., Kraemer, W.J., ... & Oliver, J.L. (2016). National Strength and Conditioning Association position statement on long-term athletic development. *J Strength Cond Res*, 30(6), 1491-1509. <https://doi.org/10.1519/JSC.0000000000001387>
- Macnamara, B.N., & Maitra, M. (2019). The role of deliberate practice in expert performance: Revisiting Ericsson, Krampe & Tesch-Römer (1993). *R Soc Open Sci*, 6(8), 190327. <https://doi.org/10.1098/rsos.190327>
- Malina, R.M. (2010). Early sport specialization: Roots, effectiveness, risks. *Curr Sports Med Rep*, 9(6), 364-371. <https://doi.org/10.1249/JSR.0b013e3181fe3166>
- Martin, E.M., Ewing, M.E., & Oregon, E. (2017). Sport experiences of Division I collegiate athletes and their perceptions of the importance of specialization. *High Abil Stud*, 28, 149-165. <https://doi.org/10.1080/13598139.2017.1292894>
- Moesch, K., Elbe, A.M., Hauge, M.L., & Wikman, J.M. (2011). Late specialization: The key to success in centimeters, grams, or seconds (cgs) sports. *Scand J Med Sci Sports*, 21(6), e282-e290. <https://doi.org/10.1111/j.1600-0838.2010.01280.x>
- Moseid, C.H., Myklebust, G., Fagerland, M.W., & Bahr, R. (2019). The association between early specialization and performance level with injury and illness risk in youth elite athletes. *Scand J Med Sci Sports*, 29(3), 460-468. <https://doi.org/10.1111/sms.13338>
- Murase, N., Katsamura, T., Ueda, C., Inoue, S., & Shimomitsu, T. (2002). Validity and reliability of Japanese version of International Physical Activity Questionnaire. *J Health Welf Stat*, 49, 1-9. (in Japanese).
- Myer, G.D., Jayanthi, N., Difiori, J.P., Faigenbaum, A.D., Kiefer, A.W., Logerstedt, D., & Micheli, L.J. (2015). Sport specialization, Part I: Does early sports specialization increase negative outcomes and reduce the opportunity for success in young athletes. *Sports Health*, 7(5), 437-442. <https://doi.org/10.1177/1941738115598747>

- Myer, G.D., Jayanthi, N., DiFiori, J.P., Faigenbaum, A.D., Kiefer, A.W., Logerstedt, D., & Micheli, L.J. (2016). Sports specialization, part II: Alternative solutions to early sport specialization in youth athletes. *Sports Health*, 8(1), 65-73. <https://doi.org/10.1177/1941738115614811>
- Post, E.G., Bell, D.R., Trigsted, S.M., Pfaller, A.Y., Hetzel, S.J., Brooks, M.A., & McGuine, T.A. (2017). Association of competition volume, club sports, and sport specialization with sex and lower extremity injury history in high school athletes. *Sports Health*, 9(6), 518-523. <https://doi.org/10.1177/1941738117714160>
- Rees, T., Hardy, L., Güllich, A., Abernethy, B., Côté, J., Woodman, T., ... & Warr, C. (2016). The Great British Medalists Project: A review of current knowledge on the development of the world's best sporting talent. *Sports Med (Auckland, N.Z.)*, 46(8), 1041-1058. <https://doi.org/10.1007/s40279-016-0476-2>
- Simon, H.A., & Chase, W.D. (1973). Skills in chess. *Am Sci* 61, 394-403.
- Simon, J.E., & Docherty, C.L. (2017). The impact of previous athletic experience on current physical fitness in former collegiate athletes and noncollegiate athletes. *Sports Health*, 9(5), 462-468. <https://doi.org/10.1177/1941738117705311>
- Solberg, P.A., Hopkins, W.G., Paulsen, G., & Haugen, T.A. (2019). Peak age and performance progression in world-class weightlifting and powerlifting athletes. *Int J Sports Physiol Perform*, 14(10), 1357-1363. <https://doi.org/10.1123/ijsp.2019-0093>
- Sorenson, S.C., Romano, R., Azen, S.P., Schroeder, E.T., & Salem, G.J. (2015). Life span exercise among elite intercollegiate student athletes. *Sports Health*, 7(1), 80-86. <https://doi.org/10.1177/1941738114534813>
- Swindell, H.W., Marcille, M.L., Trofa, D.P., Paulino, F.E., Desai, N.N., Lynch, T.S., ... & Popkin, C.A. (2019). An analysis of sports specialization in NCAA Division I collegiate athletics. *Orthop J Sports Med*, 7(1), 2325967118821179. <https://doi.org/10.1177/2325967118821179>
- Vaeyens, R., Güllich, A., Warr, C.R., & Philippaerts, R. (2009). Talent identification and promotion programmes of Olympic athletes. *J Sports Sci*, 27(13), 1367-1380. <https://doi.org/10.1080/02640410903110974>
- Zwiers, R., Zantvoord, F.W., Engelaer, F.M., van Bodegom, D., van der Ouderaa, F.J., & Westendorp, R.G. (2012). Mortality in former Olympic athletes: Retrospective cohort analysis. *BMJ (Clin Res Ed)*, 345, e7456. <https://doi.org/10.1136/bmj.e7456>

