The Relationship Between Sport Specialisation, Participation Volume, and Injury History in New Zealand Youth Basketball.

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Abstract

The surge in youth basketball participation in New Zealand (NZ) prompts an investigation into the associations between participation volume, sport specialisation, and injury history among young New Zealand basketballers. With secondary school basketball witnessing a 45% increase in participation over the last two decades, concerns have been raised about players specialising and the potential for increased injuries. This dissertation aims to address three key research questions: (I) Is there an association between sports participation volume and injury history? (II) Is there an association between sports specialisation (in basketball) and injury history? (III) Does the ratio of organised sports participation to free-play relate to injury history in young New Zealand basketball players?

This cross-sectional study surveyed three hundred and sixty-six (50% male, aged 10-19) New Zealand basketball players from the 2020 Basketball New Zealand (BBNZ) junior nationals' selection camp. Electronic tablets with SurveyMonkey were used to gather the data on sports specialisation, injury history, weekly sport participation volume, and free-play hours over the previous 12 months. A previously published questionnaire (McGowan et al., 2020) was adapted for basketball-specific purposes. One-way ANOVA, Pearson's Chi-squared test, and multiple logistic regression analyses adjusted for sex, age, and participation hours, assessed associations between sport specialisation, sport participation volume recommendations, and injury outcomes. The threshold for statistical significance was set at $p<0.05$. Fifty-five per cent of players reported at least one injury, with lower-limb injuries constituting 70% of total injuries. Forty-six per cent were highly specialised, 40% moderately, and 14% low specialised. Weekly sport participation volume averaged 9.5 ± 4.67 hours, with no significant differences between specialisation groups. Over half of the participants exceeded the 2:1 organised sport-to-free-play ratio, and 88% played basketball for more than 8 months per year. After adjusting for age, gender, and weekly participation hours, neither medium nor highly specialised players showed increased odds of 'any injury' or 'lower limb injury' compared to the low specialisation group. Males had significantly higher odds of reporting any injury, while the medium specialisation group was less likely to report lower limb injuries than the low specialisation group. Exceeding participation volume recommendations showed no significant association with injury history.

Our study of New Zealand youth basketball players found a higher prevalence of high specialisation (46%) compared to previous studies (McGowan et al., 2020). Exceeding

participation volume recommendations showed no significant association with injury history, challenging established norms. Notably, basketball players who participated for more than 8 months per year did not exhibit increased odds of injury, contrary to previous literature. Recreational free-play did not show a protective effect, possibly reflecting changing activity patterns among young athletes. While our study provides valuable insights, limitations include potential recall bias, a lack of injury detail, and a lack of generalisability outside the New Zealand basketball population. Further research is necessary to further our understanding of youth sports specialisation and participation volume, considering regional and sport-specific factors.

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Attestation of Authorship

I declare that this submission is a product of my creation, and to the best of my knowledge and belief, it contains no material that has been previously published or authored by another individual. All sources used in the preparation of this dissertation have been appropriately cited, and any material that has been quoted or paraphrased has been attributed to its source. I further declare that this submission has not been presented for the award of any other degree or diploma from a university or other institution of higher education unless due acknowledgement is made.

Andreas Fossum
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Candidate Contributions to Co-Authored Papers

Chapter 3 Prepared for submission to *New Zealand Journal of Sports Medicine.*	Fossum 80% Whatman 10% Kung 10%

We, the undersigned, hereby agree to the percentages of participation to the chapter identified above.

Andreas Fossum	Chris Whatman	Jaron Kung

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Ethical Approval

Ethical approval for the collection of data for this research was granted by the Auckland University of Technology Ethics Committee (AUTEC) on October 19, 2022. Number 20/46.

Chapter 1: Introduction

1.1 Background

Youth basketball has seen rapid growth over the last decade. With the increased popularity of the sport, there has also been a focus on competition, organised practice, and a reduction in unstructured free-play (Moseid et al., 2018; LaPrade et al., 2016; Jayanthi et al., 2021; McGowan et al., 2020). In New Zealand (NZ), participation in secondary school basketball increased by 45% in the last two decades (School Sport New Zealand, n.d.). With an increase in the number of children involved in organised basketball, more are choosing to specialise in this sport, often in an attempt to gain a competitive advantage (Bell et al., 2018; Post et al., 2019).

The latest consensus by Bell et al. (2021) defines sports specialisation as deliberate and focused engagement in one sport for most of the year, thereby restricting involvement in other sporting activities. Numbers on the prevalence of sport specialisation in NZ adolescents suggest a range from 25% (McGowan et al., 2020) to 43% (Zoellner et al., 2022). The prevalence of sport specialisation overseas ranges from 13% (McGuine et al., 2017) to as high as 73% in youth basketball (Meisel et al., 2021). These numbers depend on a range of variables, such as sport, sex, age, school size, and geographic location (McGowan et al., 2020). Literature suggests rates of prevalence may increase with age and as competition increases (Post et al., 2017A). Specialising in one sport at a young age has been linked to several negative outcomes, including overuse injuries, burnout, and dropout (Bell et al., 2018; DiFiori et al., 2014; Myer et al., 2015; Benson et al., 2021).

Several studies reported that specialising in one sport at a young age significantly increases your injury risk (Fabricant et al., 2016; Whatman et al., 2023; Campbell et al., 2021; Post et al., 2017B; Post et al., 2017A; Hall et al., 2016). On the other hand, other studies have indicated that there is no association between the level of specialisation and injury risk (Moseid et al., 2018; Whatman et al., 2021; Meisel et al., 2021; McGowan et al., 2020; Weekes et al., 2019). Several studies found no increased risk between sport specialisation and acute injuries but did find an association with overuse injuries (Bell et al., 2018; Zoellner et al., 2022; Leppanen et al., 2015). Varying demands and injury risks associated with different sports are likely to affect the results. Sports that involve high-

frequency repetitions of movements with significant loading forces (i.e., jumping and change of direction) are likely to place more strain on the lower limbs and increase the likelihood of injury. (Post et al., 2020 & Benson et al., 2021). After controlling for training volume, a USbased study found an association between sport specialisation and injury in volleyball but not in basketball and soccer players (Post et al., 2020), while a New Zealand study did find an independent association in soccer (Zoellner et al., 2020). The association between injury and sport specialisation is likely dependent on several factors such as the different demands of each sport and further research is needed to gain a better understanding of the association with injury in basketball.

Excessive structured sports participation among young athletes can have potential downsides, including a possible reduction in unstructured free-play (LaPrade et al., 2016). This could increase the risk of injury, as unstructured, self-organised free-play has been found to have a positive effect on protecting against injury (McGowan et al., 2020). Research indicates that youth athletes should not participate in one sport for more than eight months of the year, nor should weekly hours of sports participation exceed the players' age in years. The ratio of organised sports should not exceed double the amount of free-play (Jayanthi et al., 2019). More research is needed to assess the association between exceeding these volume recommendations and injury risk in specific youth sports, including basketball.

1.2 Statement of the Issues

1.2.1 Adolescent Sports Injuries: A Growing Concern in New Zealand

Sport-related injuries in adolescents have been on the rise over the past two decades. An Australian study reported a 61% increase between 2003 and 2012 (Shee et al., 2016). In New Zealand, the Accident Compensation Corporation (ACC) reported a 19% rise in sport-related injuries among individuals under the age of 18 from 2012 to 2017, and a 26% increase in musculoskeletal injuries among 10-14-year-olds (Accident Compensation Corporation, 2019). Among team sports, basketball had the third highest number of new claims in 2022, with over 20,000 new sport injury claims (Accident Compensation Corporation, 2022). However, these numbers probably only capture acute injuries reported by healthcare professionals, potentially overlooking gradual onset and overuse injuries. This leaves a significant knowledge void around adolescent sports-

related injuries in NZ, especially if you take into consideration that, according to DiFiori et al. (2014) overuse and gradual-onset injuries contribute to as much as 53% of all injuries related to sports in adolescents. A study by McGowan et al. (2020) on multiple different sports in NZ found that out of a total of 1536 unique sport-related injuries, 22% of them were categorised as gradual-onset injuries. Despite this, there is a lack of recent data on the prevalence of overuse injuries in adolescent sports in New Zealand that covers specific sports like basketball.

1.2.2 The Evolution of Adolescent Sport Practice

Over the past two decades, adolescent sports practice has undergone a significant shift, both in New Zealand and internationally. There has been a growing trend towards more structured, frequent, and intensive sports from a young age, largely driven by sociological and economic factors (Hainline, 2019). The focus on achieving a successful sports career with high financial gains, academic scholarships, and elite performance pathways supported by national organisations has given rise to increasing numbers of youth athletes specialising early in a single sport (Buckley et al., 2017; Carder et al., 2020).
This approach is often justified by what many know as the 10,000-hour “rule”, stating that 10,000 hours of purposeful practice are required to achieve elite status (McGowan et al., 2020). However, this rule was originally derived from research on elite violinists and has been misquoted and popularised in sports literature. Despite this, the popularity of sports specialisation has led to the emergence of new opportunities in New Zealand basketball, including early talent identification programs, representative teams, youth sports academies, playing with older athletes or adults, large regional representative tournaments for pre-adolescents, and holiday programmes that are all focused on basketball. As a result, children in New Zealand are increasingly engaging in intensive and specialised basketball practice.

1.2.3 Sport Specialisation: Risks and Rewards for Adolescent Athletes

Intensive participation in sport including large amounts of organised practice and competition has been linked with several negative outcomes such as higher risk of injury, burnout, social isolation, and drop-out from sport. Despite these negative consequences, some still argue that specialised practice under the proper supervision is needed to develop the necessary skills for future success (Ahlquist et al., 2020). Studies have also shown that participating in multiple sports during adolescence can lead to greater success in the long run (Buckley et al., 2017 & Gallant et al., 2017). The appropriate age

for sport specialisation is still up for debate, but it is generally suggested that it should not occur before the age of 13 and highly specialised pathways tend to begin around age 16 (Vierimaa et al., 2012). A lack of evidence addressing the effects of sport specialisation and intensive participation on the 10-13-year-old demographic leaves an uncertainty of when it is appropriate to specialise.

1.2.4 Current Recommendations for Preventing Injuries in Adolescent Athletes

Young athletes face an increased risk of overuse injury and specialising in sport at a young age may contribute to the increased risk (Gianoudis et al., 2008). Therefore, guidelines for preventing adolescent injuries strongly recommend that sports specialisation should be avoided until late adolescence (Bergeron et al., 2015). In addition to avoiding sports specialisation, volume-based recommendations have also been proposed to prevent overuse injuries in adolescent athletes (Bergeron et al., 2015). For example, children exceeding more hours of organised sports per week than their age in years or participating in over double the amount of organised training compared to free-play are at an elevated risk of overuse injuries and should be closely monitored (McGowan et al., 2020). Similarly, those who engage in a single sport for over eight months in a year should also be monitored to avoid overuse injuries (Post et al., 2018). Healthcare providers need to ensure that recommendations for specialisation and participation volumes are supported by sound research when treating injured adolescent athletes. While reducing injuries should be the primary focus, promoting lifelong participation in sports and helping athletes achieve their goals is also essential. Therefore, clinicians should not overlook the importance of these goals and should incorporate them into their treatment plans. Doing so may help injured adolescent athletes recover and continue to participate in sports throughout their lives.

Aim and Research Questions

Aim

This dissertation aims to investigate the associations between participation volume, sport specialisation, and injury history in young New Zealand basketball players.

Research Questions

1. Is there an association between participation volume and injury history in young New Zealand basketball players?

2. Is there an association between sport specialisation and injury history in young New Zealand Basketball players?

3. Is there an association between the ratio of organised sports participation and free-play and injury history in young New Zealand basketball players?

Prelude to Chapter 2

A narrative literature review was conducted to examine the current evidence regarding the association between sport specialisation and increased risk of injury. A separate review was conducted to examine the current evidence on the association between sports participation volume and injury. During the search for relevant literature, it became clear that methods for rating sport specialisation and measuring sport participation volume varied widely. The variety of methods made it more challenging to decide what studies to include in the review.

Chapter 2: A Literature Review

2.1 Introduction

This chapter aims to review and summarise the academic literature related to sport specialisation, participation volume, as well as the ratio of organised practice to free-play and their association with musculoskeletal injury in adolescents. This chapter will provide a narrative review of the methodologies used to evaluate sport specialisation, exploring the prevalence of specialisation in youth sports, and the association between sport specialisation and history of injury. This chapter will also review the literature investigating the association between the volume of organised sports participation among young athletes and its impact on musculoskeletal injury, as well as present different methods of recording volume exposure in adolescent sports research and summarise the volume-based recommendations advocated in current injury prevention guidelines. Finally, this literature review will focus on the potential impact of free-play on injury history in adolescents.

In July 2022, an extensive literature search was undertaken to gather relevant studies using a mixture of the Auckland University of Technology Library database, Google Scholar, and Pubmed. Terms included in the search were “sport specialisation, youth, injury, training volume, organised sport, and basketball”. Table 1 presents a summary of the studies reviewed. A separate literature search to identify relevant studies reporting on sport participation volume and its association with injury in youth athletes was conducted in July 2022 using a combination of the Auckland University of Technology library database, Google Scholar, and Pubmed. Search words included “training volume, injuries, adolescent, youth, athlete, and training load”. The search was restricted to peer-reviewed journals published in English. Studies were only included if they involved participants 20 years of age or younger. A summary of the findings of the studies reviewed in this section can be found in Table 2.

Table 1. Overview of studies on sport specialisation and association with injury

Author	Study design	Participants	Sports	Outcomes	Association between specialisation and injury
Campbell et al. (2021)	Prospective cohort study	N = 895 American High School Freshmen	Variety of sports not specified	216 (24.1%) categorised as specialised Specialised athletes were significantly more likely to report an injury 39.8% vs 33.2%	Specialised athletes were significantly more likely than non-specialised athletes to report an injury (39.8% vs 33.2%, p< 0.0271)
Jayanthi et al. (2020)	Case-control study	N = 579 Youth athletes from primary care sports medicine clinics in Chicago, Illinois, USA Mean age = 14.05 yrs (range 7-18 yrs) 53% female	Sports not specified	161 (28%) of the participants were categorised as highly specialised. 421 (73%) of the participants reported an injury.	Highly specialised athletes had 1.72 times greater odds of an injury than low specialised athletes (95% CI, 1.352.20)

McGowan et al. (2020)	Cross sectional survey	N = 914 59% female New Zealand youth Age = 12.6 ± 0.5 yrs	Basketball, football, swimming, futsal, netball, field hockey, water polo, tennis, rugby, and gymnastics	231 (25%) categorised as highly specialised 1536 unique injuries reported 78% acute injuries 22% gradual onset	No association between high specialisation and injury. Association between highly specialised sport participation and any type of injury after adjusting for weekly training hours compared to age, ratio of organised to free-play, and participating in the same sport for more than 8 months of the year: 95% CI: 0.88 (0.59-1.31) P value 0.53
McGuine et al. (2017)	Prospective cohort study	N = 1544 (49.5% male) American High School athletes Mean age 16.1 ± 1.1 yrs	Variety of sports	13% categorised as highly specialised 276 (15.2%) reported a lower extremity injury 23% reported a gradual onset injury	Highly specialised athletes were found to be at a significantly greater risk of suffering from gradual or recurrent injuries compared to athletes with low specialisation ratings. incidence of lower extremity injuries for highly specialised participants was higher than for low specialisation (HR, 2.10 [95% CI, 1.323.35]; *P* = .002)

Meisel et al. (2021)	Cross-sectional study, convenience sample	N = 772 627 Male Youth Basketball players Mean age 16.6 yrs (boys) 14.9 yrs (girls)	Basketball	476 (73% were specialised in Basketball 116 (15%) reported an injury that kept them from playing for a month or longer	No significant relationship between early specialisation and basketball related injury. Relationship between specialising in basketball and sitting out from basketball for one month or longer with a basketball injury: 11yrs or younger: 1.1[0.5-2.4] p=0.718 11yr-13yr: 0.8[0.3-1.8] p=0.543 14yrs or older: 1.9[0.57.2] p=0.317
Post et al. (2017A)	Case-control study	N = 2011 (51% male) American athletes Mean age 13.7 ± 1.6 yrs (range 12-18 yrs)	Variety of sports	37% categorised as highly specialised 992 total injuries 377 overuse injuries	Compared to athletes with low specialisation ratings, those who were highly specialised had a significantly greater likelihood of reporting a history of injury. *P* < .001; OR, 1.59; 95% CI, 1.26-2.02

Post et al. (2017B)	Cross-sectional study	N = 1544 (49.5% male) American High School athletes Mean age 16.1 ± 1.1 yrs (range 12-18 yrs)	Variety of sports not specified	207 (13%) categorised as highly specialised 487 (31.5%) reported a history of lower extremity injury	After adjusting for gender, individuals with a high level of specialisation have notably higher chances of reporting a previous lower extremity injury. 95% CI: 2.58 (1.88-3.54) p <0.001
Post et al. (2021)	Cross-sectional study	N = 805 29.9% female Mean age12.9 ± 2.5 yrs	Basketball	189 (23.5%) categorised as high specialisation 204 25.3%) reported injuries 35.4% of high specialisation group reported an injury vs. 14.5% of low specialisation group	Highly specialised basketballers had a higher likelihood of reporting an injury. 95% CI: 2.47 (1.25-4.88), P=0.009
Post et al. (2021)	Cross-sectional study	N = 246 241 Male Little League Baseball Age = 9.5 ± 1.6 yrs (Range 7-12yrs)	Baseball	29 (11.8%) categorised as highly specialised .	Highly specialised Little League players exhibited inferior throwing arm health compared in comparison to lowspecialisation players. (95%CI, 0.59 [0.2-1.0])

Weekes et al. (2019)	Prospective study over 4 years	N = 602 High School Students	Soccer, baseball, swimming, softball.	255 (42.4%) categorised as specialised During the 4-year period 9% of specialised athletes sustained an injury vs. 5.2% of non-specialised	56.5% of the specialised athletes had been injured playing their primary sport, compared to 43.5% of non-specialised athletes, p= 0.046. Not statistically significant.
Whatman et al. (2021)	Cross-sectional study	N = 238 (49% male) Canadian Junior High School Students Mean age = 12.6 yrs (range 11-16 yrs)	Multiple sports, mainly soccer, basketball hockey and dance	19% of the girls and 17% of the boys categorised as high specialisation 19% of the students reported an injury (76% lower extremity)	No independent association between injury history and level of specialisation. (95% CI: 2.21 (0.43 to 11.37) Girls had a higher likelihood of reporting an injury compared to boys. (95% CI: 2.21 (0.43 to 11.37)
Whatman et al. (2023)	Secondary analysis of cross-sectional study	N = 1504 (49% Male) Canadian high school Students Median age = 16yrs (range 14-19yrs)	Basketball, badminton, soccer, volleyball, dance, running, ice hockey, swimming, American football, alpine skiing	462 (31%) categorised as highly specialised 682 (46%) reported a history of musculoskeletal injury	Highly specialised students report more musculoskeletal injuries. Incidence rate ratio (IRR) 5 1.36, 95% confidence interval (CI), 1.07-1.73]

Zoellner et al. (2022)	Cross-sectional survey	N = 414 211 Male New Zealand Football Age = 12.8 ± 1.1 yrs	Football	172 (43%) categorized as highly specialised 287 (84%) of participants reported an injury in the past 12 months	Participants that were highly specialised were 4.2 times more likely to report a gradual onset injury. 95%CI = 1.48–11.74, P = 0.01 No significant associations were found with acute injuries 95% CI = 0.35 (0.10–1.20) p = 0.10

2.2 Summary of Studies Reviewed on Sports Specialisation and Association With Injury.

Of the 13 studies included in this part of the review, three were prospective studies, eight were cross-sectional studies, and two were case-control studies. All the included studies were published between 2017 and 2023. Across the 13 studies included, there were 12068 participants. The age range of all participants was 7-18 years. Of the 13 studies, 9 indicated athletes categorised as highly specialised were more likely to report a history of injury, while 4 studies suggested there was no significant difference between highly specialised and non-specialised athletes. It is important to note that methods and definitions of specialisation differed between the studies.

2.3 The Lack of a Standardised Method for Rating Sport Specialisation

Recently, there has been an increase in the popularity of the topic of sport specialisation. The increased interest may be due to the increase in popularity of youth sports and their competition level and the perceived idea that specialising in one sport at a young age comes with an early competitive advantage. There are a variety of definitions of sports specialisation in the literature. Some focus on the amount of time and commitment devoted to a single sport, while other authors focus on the exclusion of other sports (Jayanthi et al., 2013). The most cited definition of sport specialisation is the one proposed by Jayanthi et al. (2013), which defines sport specialisation as "intense, year-round training in a single sport with the exclusion of other sports." Bell et al. (2021) reported on a recent consensus that stated, "Sports specialisation involves intentional and focused participation in a single sport for a majority of the year that restricts opportunities for engagement in other sports and activities." Currently, there is no single, standardised method for rating sport specialisation. Several methods have been proposed in the literature for rating sport specialisation. The most common method is the three-point scale suggested by Jayanthi et al. (2015). This scale classifies young athletes into low, medium, or highly specialised groups based on the following three questions: (1) Have you picked a main sport? (2) Did you quit other sports to focus on that main sport? (3) Do you train for more than 8 months of the year in that main sport? Despite some criticism from Myer et al. (2015) that this method may misclassify highly specialised athletes as moderately specialised, Jayanthi's (2015) three-point method remains the most popular in literature. In contrast, Bell et al. (2016) found that the three-point scale was a more accurate way to rate specialisation compared to other methods. Jayanthi et al., (2020) added a question to the three-point scale that asked if the players quit all other sports before
12 years of age. If the players answered, 'yes' to this question as well as the original 3 questions, they would be classified as 'extremely specialised'. Other studies have used simpler methods, such as identifying whether participants consider themselves single or multisport, whether they play one sport year-round or multiple sports year-round, or the athletes age in years when they withdrew from other sports to focus on their main sport (McGowan et al., 2020). One basketball study defined sport specialisation as 'participation in organised basketball with no organised participation in any other sports' (Meisel et al., 2021), while another defined sport specialisation as 'participating in a particular sport for more than 6 months (Weekes et al., 2022).

There are pros and cons to the methods described above. For example, categorising specialisation based on whether the young athletes consider themselves to be single or multisport is a very simple method and could be easy to implement. However, it is also a very subjective method and could be very open to individual interpretation and potentially cause difficulty in comparing future studies. It also does not give us any information regarding sports participation volume or intensity. The three-point scale allows us to categorise the young athletes into levels of specialisation which can be very useful when comparing young athletes with a similar level of sports participation. It is also more specific and objective and is not as open to individual interpretation, which may be beneficial when comparing future studies. The three-point scale does require young athletes to have a good understanding of their sports participation, and it is more time-consuming to gather the information. It also lacks any information regarding participation hours and intensity.

The lack of a standardised method for rating sports specialisation impacts the ability to compare studies as the different methods used may be the reason for varying results. The lack of a standardised method may also limit the ability to draw accurate conclusions about the effect of sports specialisation because it is likely the effects could vary depending on how sports specialisation was defined and how it was measured (Miller et al., 2019). The lack of a standardised method is also likely to lead to the misclassification of athletes and will need to be addressed to ensure that studies are more reliable and comparable and that the results can be used to inform decisions about athlete development.

2.4 Trends in Adolescent Sport Specialisation Prevalence

Across the studies analysed, the proportion of athletes who were highly specialised or specialised in a single sport ranged from 13% to as high as 73%. Zoellner et al. (2022), Meisel et al. (2021), and Campbell et al. (2021) discovered that females exhibited a lower prevalence of high specialisation compared to males. In contrast, Post et al. (2017A), Post et al. (2017B), and McGuine et al. (2017) found that females had a higher prevalence of sport specialisation. Whatman et al. (2023) showed a very similar rate of high specialisation between males (32.2%) and females (29.4%). It is important to note that the method for rating specialisation differed between these studies. For example, Campbell et al. (2021) measured specialisation as ‘participating in one sport over 6 months of the year’. This method is likely to fit a very large number of athletes, and when compared to the three-point scale, it could misclassify the young athletes into any of the three specialisation categories (low, medium, or high).

The studies looking at basketball specifically ranged significantly, with a study from McGuine et al. (2017) showing a specialisation rate of 13%, Post et al. (2017A) showing a basketball specialisation rate of 23.5%, and a study by Meisel et al. (2021) finding that 73% of the participants were specialised in basketball. It is important to note that the methods for rating specialisation between these studies also differed and that this is likely the main reason for the different results. Meisel et al. (2021) measured specialisation as any student who "participates in basketball only, without participating in any other sport". Again, when compared to the three-point scale, this could misclassify the basketballers into any of the three specialisation categories. A study on multiple sports from New Zealand showed an average level of 25% high specialisation across multiple sports (McGowan et al., 2019), while a study by Zoellner et al. (2022) found that 43% of New Zealand soccer players were classified as high specialisation. Zoellner et al. (2022) and Post et al. (2017B) found that school size played an important role in the level of sport specialisation, while Whatman et al. (2021) found no significant difference in rate of specialisation between different school sizes.

There were 12068 total participants across the 13 studies in this review, with a mean age of 13.9 years old. Several studies showed that as age advanced, so did the degree of specialisation (Zoellner et al., 2022; Post et al., 2017A). According to other studies, the number of athletes who specialised in a particular sport reached its highest point at 15 years old and then began to decrease after 16 years old (Post et al., 2017A). When categorising sports as a team or individual sports, McGuine et al. (2017) suggest that team sports like baseball (19.1%), basketball (13.1%) and soccer (21.5%) had a higher prevalence of sport specialisation compared to track and cross-country athletes (0%), while tennis players had a similar prevalence of sport specialisation to the team sports (17.9%). One reason for the higher percentage of specialised athletes in team sports could be due to the dynamic requirements of the sport. For example, in basketball, several separate training sessions might be required to cover aspects of individual skills like shooting, passing, and dribbling. In addition to the individual elements, there are also team-based elements like how to play together on offence and defence and when combined, these aspects of the sports take up several training sessions in a week, leaving little time for other sports.

Based on the studies in this review, specialisation varies across sports, gender, age, and geographical location. The current literature on the prevalence of sports specialisation faces challenges due to inconsistent use of methodologies and a limited number of participants per sport. Addressing these issues by developing standardised definitions and providing larger

samples for specific sports is crucial for a comprehensive understanding of sports specialisation across different contexts.

2.5 Sport Specialisation and Association With Injury

The relationship between sport specialisation and injury history in adolescent athletes is complex and, to date, lacks any definite answer. While some studies have found a positive association between the two, others have not. The strength of the association appears to vary depending on the sport, the level of specialisation, methods for rating specialisation, and the definition of injury. Of the 13 studies analysed, 9 suggested that highly specialised athletes were more likely to sustain an injury (Jayanthi et al., 2020; Post et al., 2021; McGuine et al., 2017; Post et al., 2017A; Post et al., 2017B; Campbell et al., 2021; Zoellner et al., 2022; Post et al., 2021 & Whatman et al., 2023), while 4 studies suggested there was no significant difference between highly specialised and non-specialised athletes (Whatman et al., 2021; Weekes et al., 2019; McGowan et al., 2020 & Meisel et al., 2021).

Prospective cohort studies are considered the gold standard method for finding correlations between two variables as they can establish a cause-and-effect relationship. In one of the few prospective studies, McGuine et al. (2017) found that high school athletes categorised as moderately or highly specialised were significantly more likely to sustain a lower extremity injury than those who were not specialised This association persisted after adjusting for variables like gender, competition volume, age, and previous injury history. However, not all studies have found a significant association between sport specialisation and injury. For example, Weekes et al. (2019) conducted a four-year prospective study and found no statistically significant association between specialisation and reported injuries over four years. Similarly, Meisel et al. (2021) conducted a cross-sectional study of 772 basketball players and did not identify any significant association between specialisation and the likelihood of reporting a history of injury. It is worth noting that the length of the observation period in these studies can have an impact on their reliability. Longer observation periods, such as the one used in Weekes et al. (2019) and Jayanthi et al. (2020) where subjects were followed throughout high school (4 years and 3 years respectively), may lead to a higher number of total reported injuries, potentially strengthening the relationship between injury and specialisation. Despite this, the recent prospective study did not find a significant association between sports specialisation and increased injury risk (Weekes et al., 2022). It is worth noting that the method for rating specialisation in this study was that any student who participated in a particular sport for more than 6 months of the year was considered to be specialised. It is

possible that a portion of the 42% that were categorised as specialised could have been categorised as medium or low specialisation using the 3-point system. In contrast to Weekes et al. (2022), Jayanthi et al. (2020) did find an association between injury and specialisation using an extended version of the 3-point system. These conflicting findings highlight the need for one unified method of rating specialisation.

Campbell et al. (2021) suggested that specialised student-athletes, in addition to being at a greater risk of reporting an injury, also tend to report significantly more injuries than non-specialised athletes and that these injuries tend to be more severe. Larger case-control studies have provided further evidence supporting the association between specialisation and injury even after controlling for variables such as gender, degree of specialisation, and age (Post et al., 2017A; Jayanthi et al., 2020). Gender appears to be an important confounding factor, with recent studies showing that adolescent female athletes are more likely to report overuse-type injuries compared to their male counterparts (Campbell et al., 2021; Jayanthi et al., 2020; Post et al., 2017B), even when the degree of sport specialisation was found to be lower in females (Jayanthi et al., 2020). Post et al. (2017A) agreed that females tend to have a higher risk of injury, however, in contrast, they found that females were more likely to be highly specialised compared to males. In the study by Whatman et al. (2023) specialisation rates between males and females were almost identical, however, females were more likely to report an injury of any kind apart from concussions compared to males. In contrast, McGuine et al. (2017) found no difference in injury incidence between males and females, even when females were more likely to be highly specialised. These findings likely highlight the vast differences specific sports make in the level of sport specialisation and risk of injury. More research is needed on specific sports to get a better understanding of the impact each sport has on the reported level of sport specialisation and its association with injury.

A study by Zoellner et al. (2022) reported that of a group of 414 young New Zealand footballers, 43% of them were classified as high specialisation and 84% of the participants reported an injury in the past 12 months. The same study found that the highly specialised group had over four times increased odds of a history of gradual onset injuries, while the highly specialised group showed no significantly larger risk of acute injury, suggesting that type of injury could play an important role when looking at the association with sport specialisation. However, McGowan et al. (2020) found that acute injuries accounted for 78% of a total of 1536 injuries over 12 months and that, after adjusting for relevant confounding variables, a higher level of sport specialisation did not increase the risk of any type of injury.

Post et al. (2021) published a cross-sectional study on 805 youth basketballers and found that highly specialised athletes were more likely to have reported an injury compared to low-specialised athletes. Interestingly, the same study found that athletes who played on another sports team at the same time as basketball were twice as likely to report an injury. Several published guidelines for youth sports participation advise that children should engage in various sports during their childhood to mitigate the risk of injury (DiFiori et al., 2014; Jayanthi et al., 2013; Myer et al., 2015) Other sporting authorities and medical organisations have also issued similar recommendations (ACC SportSmart, n.d), emphasising the need for young athletes to participate in multiple sports to reduce their chances of injury. The study by Post et al. (2021) suggests that this recommendation refers to participating in different sports throughout the year rather than playing multiple sports simultaneously and that If not specified, some parents may misunderstand this advice and encourage their children to participate in several sports at the same time, which could lead to excessive sport participation volume and possibly increase the likelihood of overuse injuries.

The majority of the studies reviewed found an association between specialising in a single sport during adolescence and an increased likelihood of reporting a history of injury. However, there is some variation in the results, which may be due to differences in how specialisation and injury are defined and measured, as well as variations in participation volume. There is also reason to believe that the type of sport the athlete chose to specialise in plays a significant role when looking at the association between sport specialisation and injury. Additionally, some studies suggest that participation volume, specifically the ratio of organised weekly sports to recreational free-play, may be an important factor in injury risk. The findings collectively suggest that guidelines for adolescent sports participation should emphasise variety in sports and physical activity to reduce the risk of injury.

Table 2. Overview of studies on sport participation volume and association with injury

Author	Study design	Participants	Sport	Outcome	Method for measuring participation
Ahlquist et al. (2020)	Cross-Sectional Study	N = 202 (141 female) Mean age= 20.1 yrs NCAA Division 1 athletes	Several Sports	146 Total injuries were reported. Training more than 28 hrs/week was associated with: Multiple injuries (90% vs 56.3%; OR 7.00) Injury requiring surgery (60% vs 22.9%; OR 5.05) and greater number of total injuries (2.5 vs. 2.0; U=486)	Hours/week of sport participation
Field et al. (2019)	Prospective Cohort Study	N = 10138 (68% female) Mean age = 12.5 ± 1.6 yrs Throughout USA.	Several Sports	2000 students reported at least one injury. Total hours per week of vigours activity was associated with an increased risk of developing an injury (males: HR, 1.04; 95% CI, 1.02-1.06; females: HR, 1.06; 95% CI, 1.05-1.08) Females who engaged in weekly hours of sport close to their age in years were at a significantly increased risk of injury (HR, 1.93; 95% CI, 1.342.77). No clear pattern of risk in males.	Hours/week of sport participation

Hildebrandt et al. (2021)	Prospective cohort Study	N = 91 (52 males) Elite Ski racers from a boarding school Mean age = 12.1 ± 1.3 years Austria	Ski racing	53 injuries reported (1.4 injuries per 1000 hours of training) No significant risk factor between weekly training sessions, weekly training volume or training intensity and injury $p >$ 0.05	- Number of weekly training sessions. - Total weekly sport participation in minutes. - Total training exposure per season in hours.
Jayanthi et al. (2015)	Case-Control Study	N = 1190 (51.7% male) Age range = 7-18 yrs (13.7 mean age) Sports medicine clinics USA.	Multiple sports	846 unique injuries (67.4% overuse and 32.6% acute) participating in more hours of sports per week than age in years (OR, 2.07; 95% CI, 1.40-3.05; P < .001) or exceeding a 2:1 ratio of organised sports	-Hours per week of sport participation. Exceeding a ratio of 2:1 organised sport participation to free-play. - Participating in > weekly hours of sport than age in years
Kahlenberg et al. (2016)	Cross sectional study	N = 484 (42% female) American High School athletes Mean age = 15.9 yrs (Range = 13-21 yrs)	Several Sports	Athletes who participated in a higher volume of sport reported more lifetime injuries (OR 1.001;95% CI, 1.00-1.00; p = 0.03).	Total annual sport participation hours.
McGowan et al. (2020)	Cross-sectional survey	N = 914 (538 female) New Zealand youth athletes	Several Sports	1536 unique injuries (78% acute) (22% gradual onset) >8 months 1.56 (1.102.20) any injury	Hours per week of sport participation. Exceeding a ratio of 2:1 organised sport participation to free-play. - - Participating in more than 8 months in a main sport.

		Age = 12.6 ± 0.5 years		More hours than age in years 2.47 0.95-6.42) any injury Exceeding 2:1 ratio 1.12 (0.78-1.60) any injury	- Participating in more weekly hours of sport than age in years
Møller et al. (2017)	Prospective Cohort study over 31 weeks	N = 679 (44% female) Age range = 14-18 yrs First division U18 and U16 Denmark	Handball	709 total injuries (1.4 injuries/ 1000 hours of sport participation). The highest injury rate was experienced by handball players who increased their weekly handball participation hours by 60% or more compared with those who increased by less than 20% (HR 1.91;95% CI 1.00-3.70, p = 0.05)	Hours/week of sport participation
Nagano & Oyama (2023)	Cross-sectional retrospective study	N = 1533 (762 female) Elementary, junior, High School Age = 6-18 yrs Japan	Several sports	A total of 2072 injuries were reported. The frequency of sport participation (days/week) and prevalence of any injury; 6-12 yrs: 27% (Single sport) vs 37% (multisport). p=0.11	Weekly days of sport participation
Post et al. (2017A)	Case-control study	N = 2011 (989 female)	Several Sports	992 participants reported an injury in the past 12 months (nearly 50%)	-Hours per week of sport participation. -Exceeding a ratio of 2:1 organised sport

		Athletic competitions from Wisconsin, US Age range = 12-18 yrs		>8 months increased risk of upper extremity overuse injuries (*P* = .04; OR, 1.68; 95% CI, 1.062.80) and lower extremity overuse injury *P* = .001; OR, 1.66; 95% CI, 1.222.30 More time playing organised sport (hours/week) than age in years were associated with an increased risk of reporting any injury (*P* = .001; OR, 1.34; 95% CI, 1.12-1.61)	participation to free-play. -- Participating in > 8 months in a main sport. - Participating in > weekly hours of sport than age in years
Post et al. (2017B)	Cross-sectional study	N = 1544 (780 female) High School Athletes Age = Grade 9-12	Several Sports	487 students reported 599 injuries that resulted in loss of play time. There was a significant association between high competition volume and reporting a lower extremity injury. OR = 2.08; 95% CI, 1.552.80; P < 0.001	Number of annual primary sport competitions High = >60 Moderate = 30-60 Low = < 30
Post et al. (2019)	Cross-sectional study	N = 716 (70.8% female) USA Range = 12-18yrs (mean 14.21 yrs)	Basketball Soccer Volleyball	230 total reported overuse injuries (32.3%) Participating in a single sport for over 8 months were associated with injury in Volleyball players only.(OR [95% CI], 2.0 [1.1-3.5]; *P* < 0.05)	-Hours per week of sport participation. -Participating > 16 hours of weekly sport. -Participating in > 5 days per week. -Exceeding a ratio of 2:1 organised sport participation to free-play. - -Participating in > 8 months in a main sport.

				Participating in more hrs/week than age in yrs (OR [95% CI], 2.0 [1.23.4]; *P* < 0.01), more than 5 days per week (OR [95% CI], 2.1 [1.2-3.9]; *P* < 0.05) and for more than 16 hrs per week (OR [95% CI], 2.0 [1.1-3.4]; *P* < 0.05) were only associated with injury in volleyball players. Exceeding ratio of organised practice vs. free-play was only associated with overuse injury in soccer players. (OR [95% CI], 2.4 [1.05.5]; *P* < 0.05).	
Sugimoto et al. (2018)	Cross-Sectional Study	N = 236 (100% Female) Age Range = 12-18yrs Sports Injury prevention centre	Multiple Sports	An independent association between increased hours of weekly sports participation and increased likelihood of reporting a history of lower extremity overuse injuries in females (OR = 1.091, 95% CI: 1.007 - 1.183, p = .034)	Hours/week of sport participation
von Rosen et al. (2018)	52-Week Prospective Cohort Study	N = 284 (147 female) Range: 16-18 yrs Swedish High School athletes Sweden	Multiple sports, mainly Cross-country skiing, athletics, handball, and orienteering.	326 injuries identified over the 52-week period (4.1 injuries/ 1000 hours of sport participation). Females reported more injuries than males (35.6% versus 25.4%; *P* < .001).	Hours/week of sport participation.

				Statistically significant differences between sport types ($P < .001$) Handball players had the greatest training volume (hrs/week) of all the sports and also showed the highest injury prevalence (47.2%; 95% CI = 45.7%, 48.7%; $P < .001$).	

2.6 Summary of Studies Reviewed on Sport Participation Volume and Associated Injury Risk

Of the 13 studies included in this section of the review, seven were cross-sectional studies, four were prospective cohort studies, and two were case-control studies. All the included studies were published between 2015 and 2020. Collectively, there were 20020 participants included in the 13 studies, with an age range of 7-21 years. A significant association was found between the volume of sports participation and injury in 12 out of 13 of the analysed studies. However, the magnitude of this association differed significantly across the studies, and the overall outcomes could be attributed to factors such as the definition of injury, methods for recording participation volume, type of sport, and gender. Ten of the studies included in this review included a wide range of sports, and only a few adjusted for the individual sports included in their study, thus, caution is warranted when attempting to generalise the findings of these studies to other sporting populations.

2.7 Inconsistencies in the Methods Used to Report Sport Participation Volume and Injury

Encouraging young athletes to specialise in a particular sport for a competitive advantage has become a common trend. The increase in popularity of youth sports has given rise to various opportunities in New Zealand basketball, including early talent identification programs, representative teams, youth sport academies, chances for young children to play with older kids or adults, large regional tournaments for pre-adolescents, and focused holiday programs. In addition, it is not uncommon for young athletes to represent both a school team and a club team. Consequently, children in New Zealand are increasingly participating in a larger volume of basketball practice.

Various studies have reported organised sports participation volume in different ways. The most common method is the total hours spent in training and competitions per week, ranging from 3.5 to more than 28 hours over these 13 studies (Post et al., 2019; McGowan et al., 2020; Ahlquistet al., 2020; Field et al., 2019; Post et al., 2017B; von Rosen et al., 2018; Jayanthi et al., 2015; Møller et al., 2017; Sugimoto et al., 2018). Other methods used in the studies in this review include total hours of training in a year (Kahlenberg et al., 2016), number of annual sports competitions in your primary sport with the exclusion of training sessions (Post et al., 2017B), weekly days of sport participation (Nagano & Oyama, 2023 & Hildebrandt et al., 2021),

weekly sport participation measured in minutes per week (Hildebrandt et al., 2021), and total training exposure in a season measured in hours per season (Hildebrandt et al., 2021). Additionally, several of the studies reported participation volume by indicating the number of months per year the participants engaged in their main sport (Post et al., 2019; McGowan et al., 2020; Post et al., 2017B). Finally, several studies have measured the amount of free-play the young athletes engage in (Post et al., 2019; McGowan et al., 2020; Post et al., 2017A; Jayanthi et al., 2015). These methods of quantifying participation volume all come with their pros and cons. For example, total hours per week spent participating in sport provide a comprehensive snapshot of the time commitment to organised sport but may overlook variations in the intensity of specific activities within these total hours. The total hours of training in a year can capture the overall annual commitment to sport and account for seasonal fluctuations, but they might not reflect variations in frequency and intensity over shorter time frames. The number of annual sporting competitions that exclude training might benefit from placing an emphasis on performance, and some studies suggest that injuries are more likely to occur during competition (Post et al., 2017B). However, by excluding any training sessions, there is a possibility of significantly underestimating the total time invested in the sport. Measuring how many days a week young athletes participate in sports provides a measure of regular engagement but does not account for variations in the duration of daily activities. Total hours of participation over a whole season aligns well with seasonal variations and takes into consideration participation volume during specific periods where young athletes are likely to participate in more sports, however, it might not reflect the consistent participation throughout the entire season. The number of months participating in a main sport highlights the duration of engagement and considers year-round participation but may not distinguish between active competition months and pre- and post-season training. Finally, measuring the amount of free-play reinforces the importance of unstructured play in overall youth athlete development, however, free-play may be difficult to quantify, and the definition of 'free-play' varies across studies.

Another significant limitation when comparing these studies is the variability in the definitions of injury. Of the 13 studies reviewed, almost equally as many individual definitions of injury were reported. Some of the definitions include injuries that caused the participants to seek medical care from a medical provider (Post et al., 2017A), injuries that caused you to miss at least one week of sport (Ahlquist et al., 2020; Nagano & Oyama, 2023), retrospectively asking parents if a doctor has ever diagnosed their child with a series of injuries (Field et al., 2019), missed at least one day of training or competition (McGowan et al., 2020), describe injury, identify injury mechanism, estimate the number of days missed from practice or competition (Post et al., 2017A & Post et al., 2019), risk of injury based on an assessment for scapular

control (Møller et al., 2017), categorised injuries on severity (mild, moderate, severe) based on number of days missing from the sport (Hildebrandt et al., 2021), self-reported injury defined as any physical complaint that affected normal participation in training or competition with a reduction in performance (von Rosen et al., 2018). Likely, the definition of injury will significantly impact the association. For example, participants are much more likely to have experienced any physical complaint that has affected normal participation than they are to have missed out on a full week of sport or to have been diagnosed with an injury by a medical professional.

The lack of an agreed-upon method for measuring sports participation volume and a standardised definition of injury has implications for research and its application. Firstly, the diversity in methods for both measuring sports participation and the definition of injury makes it challenging to compare studies on the same topic, as it is likely that different methods could yield different results and thus may impede the establishment of cohesive guidelines. Second, the lack of standardised methods makes it difficult to draw general conclusions regarding the association between exceeding participation volume recommendations and the risk of reporting a history of injury. Third, the lack of a unified method for measuring sports participation could lead to the misgrouping of study subjects, where participants in one study may be classified as participating in a high volume of sport but classified as participating in medium or low amounts of sport in others. Likewise, participants who would be classified as injured in some studies would be classified as non-injured in others. The lack of a standardised method for measuring sport participation volume and the definition of injury is a significant obstacle that needs to be addressed to assist coaches, parents, and governing bodies in publishing evidence-backed recommendations for appropriate sport participation volume in the holistic development of young athletes.

2.8 Current Sport Participation Volume Recommendations for Adolescent Athletes

Young athletes represent a significant portion of the population that participates in sports and understanding the appropriate volume of sports participation for their age group is crucial. Participation in sports offers a large range of benefits, including physical fitness, skill development, and psychological well-being (Andreoli et al., 2018). However, sports injuries are on the rise in this population and have raised the question of how much is too much when it comes to sports participation. This section of the review aims to investigate the current recommendations for sport participation volume for adolescent athletes. Current guidelines for sports participation volume for the youth athlete population are primarily issued by medical

organisations and sports governing bodies. For example, in New Zealand and Australia, the Accident Compensation Corporation (ACC) and the Australasian College of Sport and Exercise Physicians have published position statements with guidelines for sports coaches and clinicians to educate them on the topic of injury prevention. The sport participation volume recommendations promoted vary in the literature and include: Not participating in your main sport over 8 months in a year (Post et al., 2017A; McGowan et al., 2020; Post et al., 2019), not exceeding 16 hours of organised sport per week (Post et al., 2019), not exceed more organised hours of sport participation a week compared to age in years (Post et al., 2017A; McGowan et al., 2020; Post et al., 2019), not exceeding a ratio of 2:1 of organised sport participation to free-play per week (Post et al., 2017A; McGowan et al., 2019; Post et al., 2019), and not participating on more than 5 days per week of organised training (Post et al., 2019). It is worth noting that these guidelines frequently change based on newly published research and new perspectives within the sporting and medical communities, but there is currently a lack of evidence to support these volume-based recommendations.

2.9 Association Between Exceeding Sport Participation Volume Recommendations and Injury.

It is widely accepted that participating in sport and exercise comes with multiple benefits and recommendations for a minimum amount of weekly exercise have existed for centuries. However, there has been a recent growing trend toward young athletes participating in an excessive amount of sports with the perception that this will lead to increased sporting success. (Ahlquist et al., 2020). Recent studies and governing bodies have published guidelines for the youth athlete population while they strive for athletic excellence and attempt to balance dedication with the potential injury risk associated with their sports participation. This paragraph investigates the association between exceeding sports participation volume recommendations and the associated risk of injuries among young athletes. Understanding the consequences of exceeding the recommended participation volume is crucial for preserving the wellbeing of young athletes.

Most of the studies included in this analysis examined the relationship between the number of hours that young athletes participate in organised sports per week and the incidence of injury. Most of the studies concluded that as weekly hours of organised sports increased, so did the likelihood of injury or reporting a history of injury (Ahlquist et al., 2020; Sugimoto et al., 2018; Møller et al., 2017; Jayjanthi et al., 2015; von Rosen et al., 2018; Field et al., 2019). However,

the magnitude of the association varied considerably among these studies. A prospective cohort study on 91 young elite ski racers with a mean age of 12 years found no significant risk factor between volume of sport participation or participation intensity and increased risk of either overuse or acute injuries (Hildebrandt et al., 2021). This study measured volume as the number of training sessions per week, total training hours over a whole season, and total minutes of weekly sports participation. This was also one of the only studies to include a measure of intensity using the rating scale for perceived exertion. It is not unlikely that skiing could differ significantly from court- and field-based sports when it comes to the appropriate amount of participation volume. Alpine skiing injuries may also be more closely tied to technical errors, equipment issues, and environmental factors than to training volume and intensity. It's also worth considering the elite level of these skiers, who might be likely to all have individual training programmes specifically created for injury prevention purposes. This study also had the smallest sample size and might not have captured a sufficiently diverse or large sample to observe significant associations. Another prospective cohort study with a much larger sample of over 10000 participants across a range of sports that also measured participation in hours per week found that total hours of sports participation were associated with an increased risk of developing an injury (Field et al., 2019). Unfortunately, it is difficult to compare the studies in this review as similar studies with similar study designs have used different methods for measuring participation volume. For example, the seven cross-sectional studies in this review have reported a combined total of six different methods of measuring sports participation. A cross-sectional study including 1533 young athletes between 6-18 years old that reported participation as weekly days of sport participation found that greater training frequency (more training days per week) was related to any type of injury at all ages (Nagano & Oyama, 2023). It is worth noting that this study included a wide range of sports and did not adjust for the different sports played. Other studies have also found a significant association between participating in more weekly hours of sport and an increased risk of reporting a history of injury (McGowan et al., 2020; Sugimoto et al., 2018; Field et al., 2019; Ahlquist et al., 2020), but these studies also include a large variety of sports without having adjusted for the different sports played. The lack of adjustment for the different sports becomes a limitation when analysing results as the type of sport is likely a significant contributor to whether or not the association is significant. It is likely that, although significant in total, if individual sports were adjusted for in these studies, the association for some of these sports could be insignificant. These claims are further validated by a cross-sectional study on 716 American youth basketball, soccer, and volleyball players between 12 and 18 years old, which found that after adjusting for the different sports, only volleyball players who participated in their main sport for more than 8 months of the year had significantly higher odds of reporting a history of injury (Post et al., 2019). Similarly, only soccer players who exceeded a ratio of 2:1 of organised

practice to free-play showed an increased risk of reporting a history of injury. This was not the case for basketball or volleyball players. However, the volleyball players did have an increased risk of reporting a history of injury if they participated in more hours a week of sport than their age in years if they participated for more than 5 days per week, and if they exceeded 16 hours a week of organised sport participation. Again, this was not the case for basketballers (Post et al., 2019). Furthermore, a 52-week prospective cohort study on Swedish high school athletes that adjusted for the different sports found a statistically significant difference between the types of sports (von Rosen et al., 2018). These results further validate the need for future studies to focus on individual sports.

Another interesting aspect of sports participation volume is the annual or seasonal changes in volume. Rather than looking at a total annual or weekly participation volume as a possible reason for injury risk, the short-term changes in volume could be a contributing factor (i.e., going from a low amount of participation to a high amount in a short timeframe). A 31-week prospective cohort study on first-division handball players between 14-18 years looked into the injury risk when weekly participation volume was changed by 20%, 40%, or 60% (Møller et al., 2017). The study found that injury rates were highest among handball players who increased their weekly participation hours by 60% or more compared to those who increased by 20% or less. Future studies on changes in participation volume could significantly contribute to recommendations for safe increases in weekly participation volume. These findings could likely contribute to strategies for safe returns to sport following holidays or off-seasons. Future studies will also likely need to adjust for weekly changes in participation volume to exclude the idea that large changes in weekly volume are the reason for the injury rather than the total weekly volume.

To provide evidence-based guidelines for safe participation in adolescent sports, clinicians require clear volume thresholds. Several sport medicine bodies have published guidelines, including limiting organised sports hours per week to the athlete's age in years, not playing the same sport for more than 8 months per year, and not exceeding a 2:1 ratio of organised sports hours to free-play activity hours per week (Post et al., 2019; McGowan, et al., 2020; Post et al., 2017A; Jayanthi et al., 2015). However, these recommendations possibly lack sufficient evidence to be generalised to the entire youth athlete population, especially since there is a lack of evidence from studies investigating individual sports.

2.9.1 Participating in More Hours a Week of Organised Sport Than Age in Years

A cross-sectional study on 914 New Zealand youth athletes from multiple sports found a significant association between participating in more hours of organised sport compared to the athlete's age in years and reporting a history of injury (p=0.02) (McGowan et al., 2020). Similarly, a case-control study on 2011 American youth athletes found that engaging in organised sports for more hours than their age years was associated with an increased risk of reporting any injury (p=0.001) (Post et al., 2017A). Another case-control study on 1190 American youth athletes aged 7-18 also found an association between exceeding this recommendation and increased odds of having reported a serious overuse injury (p=0.001) (Jayanthi et al., 2015). A cross-sectional study on 202 NCAA Division 1 athletes from America found that training more than 28 hours a week was associated with multiple injuries (OR 7.00) and injuries requiring surgery (OR 5.05). Although this study did not specifically use the method for exceeding weekly sports participation hours compared to the athletes' age in years, the participants in this study were younger than the hours per week reported in the study and would fit this category. It is worth noting that all these studies have included a wide range of sports in their associations and have not adjusted for the different sports played. Multiple variables could likely affect the level of the association reported in these studies, with the type of sport being one of the most likely. Another variable that is likely to affect the association is gender. A prospective cohort study on 10138 American youth athletes with a mean age of 12.5 found that females who engaged in weekly hours of sport that were 3-4 hours less than their age in years were at a significantly increased risk of injury (HR = 1.93; 95 CI, 1.34-2.77), with no clear patterns found in young male athletes (Field et al., 2019). Again, these findings suggest that perhaps these recommendations are too general and are not likely to fit a large portion of the youth athlete population.

2.9.2 Participate in One Sport for More Than 8 Months of the Year

A cross-sectional study from New Zealand found that athletes aged 12 and 13, involved in their primary sport for over 8 months annually were more likely to report a history of any injury (p=0.02) (McGowan et al., 2020). A case-control study on 2011 American athletes between 12 and 18 years old found that participating in their main sport for more than 8 months of the year showed an increased risk of both upper extremity overuse injury (p=0.04) and lower extremity overuse injury (p=0.04) (Post et al., 2017A). Both of these studies include a wide range of both team and individual sports. As identified earlier, the type of sport participated in is likely to be a significant factor in the association between participation volume and injury,

and if not adjusted for, it is difficult to conclude the association between specific individual sports and injury.

2.9.3 Exceeding a 2:1 Ratio of Organised Sport Participation to Free-play

A case-control study on 1190 American athletes between 7-18 years old from multiple different sporting codes reported that exceeding a ratio of 2:1 of organised sports participation to free-play had increased odds of reporting a serious overuse injury ($p<0.01$) (Jayanthi et al., 2015). Likewise, a cross-sectional study on 914 young athletes from New Zealand from a wide variety of different sports reported that exceeding a 2:1 ratio of organised sport to free-play did significantly increase the likelihood of reporting a history of injury ($p=0.02$) (McGowan et al., 2020). In contrast, a case-control study from America reported that out of 2011 young athletes, those who participated in more than twice the amount of organised sport compared to free-play showed no increased likelihood of reporting any injury ($p=0.391$) (Post et al., 2017A). Furthermore, a cross-sectional study from America reported that soccer players who participated in more than twice the amount of organised sport compared to free-play were more likely to report a history of injury ($p=0.05$), however, both volleyball players and basketball players showed no increased odds of reporting a history of injury (Post et al., 2019).

2.10 Conclusion

Studies examining the association between organised sports volume and injury in young athletes have used various measurements, including participation/exposure within a specified time frame, months/year, and hours/week. Most of the studies reviewed showed a positive association between increased participation volume and injury (McGowan et al., 2020; Kahlenberg et al., 2016; Nagano & Oyama, 2023; Ahlquist et al., 2020; Field et al., 2019; Post et al., 2017A; Jayanthi et al., 2015; Sugimoto et al., 2018), but variations in outcome measures, study design, injury definitions, and methods for measuring participation volume poses challenges in directly comparing findings. Overall, the findings across various studies indicate a potential association between increased participation volume in organised sport and increased risk of injury. However, this association may only exist in some populations and only under certain circumstances. Thus, caution is needed in suggesting guidelines for restricting participation volume across the entire population of youth athletes. More research is needed, using clearly defined injury definitions with cohorts that accurately represent the everyday young athlete, to establish practical recommendations for sports participation volume.

Prelude to Chapter 3

The literature review in Chapter 2 highlighted the inconsistencies in findings on the association between sport specialisation, participation volume and injury history. Also noted in the review were several factors that could affect the association, including coaching quality, training diversity, and training intensity. The review especially noted a lack of studies reporting on individual sports, which is likely to play an important role in injury risk. Chapter 3 reports on a cross-sectional study conducted to assess the association of sport specialisation and average weekly sport participation volume with injury history in New Zealand adolescent basketballers. Weekly hours of free-play were also collected to assess the possibility that free-play could have a protective effect on the risk of injury

Chapter 3: The Association of sport specialisation and average weekly sport participation volume with injury history in New Zealand adolescent basketballers.

3.1 Overview

Abstract

The surge in youth basketball popularity in New Zealand has raised concerns about the impact of sports specialisation on the well-being of young players. This study investigated the association between sport participation volume, sport specialisation, and injury history in New Zealand adolescent basketball players. A cross-sectional study was undertaken during the 2020 Basketball New Zealand junior nationals selection camp. 366 participants aged 10-19 provided data on sport specialisation, injury history, and sport participation volume. Forty-five percent of the participants reported at least one injury with medium and highly specialised basketball players showing no increased odds of reporting a history of injury. The medium specialisation group even showed lower odds of reporting a history of lower limb injuries compared to the low specialisation group. Exceeding any of the commonly reported participation volume recommendations was not associated with injury history in either the lower limb or the upper limb. These findings highlight the importance of further exploration into specific sports and suggest that sport specialisation could in some circumstances bring access to resources that mitigate injury risk.

3.2 Introduction

Youth basketball in New Zealand has surged in popularity over the past two decades, with participation in secondary school increasing by 45% over this period (School Sport New Zealand, n.d.). The belief that training exclusively in a single sport during childhood is a pathway to future athletic success may have caused a shift towards more intensive, frequent, and organised sports participation (Rugg et al., 2017). This increase in sports participation may be due to social and economic factors such as career opportunities with substantial financial rewards, academic scholarships, and pathways to elite performance and may

contribute to young athletes choosing to specialise in one sport. (Ahlquist et al., 2020). This shift has sparked concerns about sports specialisation and its impact on the overall youth sports experience in New Zealand. The latest consensus by Bell et al. (2021) defines sport specialisation as intentional and focused participation in a single sport for most of the year, limiting opportunities to participate in other sports. The prevalence of sport specialisation in New Zealand adolescents suggests a range from 25% (McGowan et al., 2020) to 43% (Zoellner et al., 2022). On a global scale, sports specialisation figures vary from 13% (McGuine et al., 2017) to a staggering 73% in youth basketball (Meisel et al., 2021). These figures depend on a range of factors, including the sport itself, gender, age, school size, geographical location, and methods for rating specialisation (McGowan et al., 2020). Studies hint that specialisation rates might increase with age and rising levels of participation (Post et al., 2017A). Furthermore, sports specialisation has been associated with a series of negative outcomes, including overuse injuries, burnout, and attrition from the sport (Bell et al., 2018; DiFiori et al., 2014; Myer et al., 2015). While a large number of studies exist on the impact of sport specialisation and its associated injury risk (Zoellner et al., 2022; Post et al., 2021; Post et al., 2017A; McGuine et al., 2017; Jayanthi et al., 2020), critical gaps in understanding remain. We lack specific insights into how factors like sport specialisation and sport participation volume manifest within a sport-specific context like basketball, especially in New Zealand. Most of the evidence on the topic comes from studies including multiple sports (Jayanthi et al., 2020; McGuine et al., 2017; Post et al., 2017B; Campbell et al., 2021). Future research should focus on specific sports, as associations between specialisation and injury could be sport specific. Cross-sectional studies can be valuable in health research as they can be used to determine the prevalence of health outcomes and their association with potential risk factors (Graham, 2010). While cross-sectional studies cannot establish causation, they can provide insights into participation patterns and the relationship between risk factors and injury, which further research and intervention strategies can benefit from (Bowling, 2002).

We aim for this research to provide researchers and healthcare professionals with information on the current state of sport specialisation and participation in organised sports and aim to provide valuable insights on the topic of youth basketball in New Zealand. Information from this study may also contribute to a better overall picture of an appropriate sports participation volume for adolescent basketballers as part of injury prevention interventions, but it may also begin a discussion on what the appropriate participation volume is for fostering the holistic development of New Zealand basketballers.

This study aims to investigate the association between participation volume, sport specialisation, and injury history in young New Zealand basketball players

3.3 Methods

3.3.1 Study Design

This study used a retrospective cross-sectional survey of New Zealand adolescent basketball players. To complete the survey, participants used electronic tablets with SurveyMonkey during the 2020 Basketball New Zealand (BBNZ) junior nationals selection camp. The survey included questions to determine the participants' level of sport specialisation (low, medium, high), injury history, average weekly participation volume, and weekly volume of free-play over the past 12 months. Free-play was defined as “any sporting activity or play that is just for fun, i.e. skateboarding, riding bikes, skiing for recreation, playing at the park or on the playgrounds, swimming at the beach or surfing”. The survey was adapted from a previous study by McGowan et al. (2020) that involved similar-aged youth.

3.3.2 Participants

Three hundred and sixty-six (fifty per cent male) adolescent basketballers from 10 to 19 years old participated in this study. Prior to participation, all parties involved, including parents and coaches, were informed of the purpose, risks, and benefits of the study before completing the consent, parental consent, or assent form (appendices A, B, and C). Ethical approval for this study was approved by the Auckland University of Technology Ethics Committee, number 20/46.

3.3.3 Data Collection

Participation in the study was voluntary, and all information gathered was anonymous. Information sheets (see Appendix D) were sent out to players, parents, and coaches prior to the camp. A team of research assistants was available to aid the participants when completing the survey. The survey included a total of 14 questions in three sections to gather demographic data, participation data, and injury history over the previous 12-month period. The sports participation questions related to average weekly participation volume, weekly free-play hours, and sports specialisation. To categorise the participants into low, medium, or high

specialisation groups, a series of previously reported questions were used and modified to be basketball specific (McGowan et al., 2020). The questions were: “Have you only ever played basketball?”, “Have you quit other sports to focus on basketball?”, “In the last 12 months, have you trained more than 8 months out of the year in basketball?”, “Do you consider basketball more important than other sports?” (every “Yes” answer scored 1 point). The question “Have you only ever played basketball” was added based on the suggestion from McGowan et al. (2020) in order to eliminate a subset of athletes who had only ever played basketball and thus could have been qualified as medium or highly specialised when in reality they were low or medium. Participants who scored a total of 0 or 1 were classified as low specialisation, a score of 2 was classified as medium, and a score of 3 was classified as high specialisation. Any participant reporting a sport-related injury during the previous 12-month period was required to indicate where on the body the injury occurred (see question 13 of Figure 2).

Figure 1. Basketball Participation Questionnaire

BASKETBALL PARTICIPATION QUESTIONNAIRE

AUT

This questionnaire asks you to report on sports you play competitively (including basketball) and injuries you have sustained playing competitive sport. Please read the instructions at the start of each section carefully. You do not need to answer any questions that you do not feel comfortable answering. ***By completing this survey, you are indicating you are happy for the information you have given to be included in this research project. Data from all completed surveys will be published in a report written by a student from AUT.***

Demographic Questions

1 Are you?

- ☐ Male
- ☐ Female

2 Year and month of birth

☐☐☐☐☐☐☐☐

3 What school do you go to?

☐☐☐☐☐☐☐☐☐☐☐☐☐

4 What school year are you currently in?

☐☐

5 Ethnicity

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Sport participation

The following questions relate to your structured basketball activities.

6 Have you only ever played basketball?

- ☐ Yes
- ☐ No

7 Have you quit other sports to focus on basketball?

- ☐ Yes – if yes, at what age? _____
- ☐ No

8 Over the last 12 months have you trained more than **8 months** out of the year in basketball?

- ☐ Yes
- ☐ No

9 Do you consider basketball more important than other sports?

- ☐ Yes
- ☐ No

PTO

10 During the **past 12 months**, what organised sport (practices and games, including basketball) have you participated in?
Please note the time spent, and indicate if the sport is in summer "S", winter "W" or all year "AY"
Summer = sport played in school terms 1 and/or 4
Winter = sport played in school terms 2 and/or 3

Mon	*Eg: Volleyball training 1 hour "S"*
Tues	
Wed	
Thurs	
Fri	
Sat	*Eg. Basketball game 1hr "W"*
Sun	

11 Outside of school hours, on average, how many **hours per week** are you involved in non-structured exercise/activity?
This refers to play, or sporting activity that is just for fun. ie Riding bikes, skateboarding, playing at the park, skiing for recreation, swimming at beach, surfing, playing on playgrounds

☐☐ Hours/week

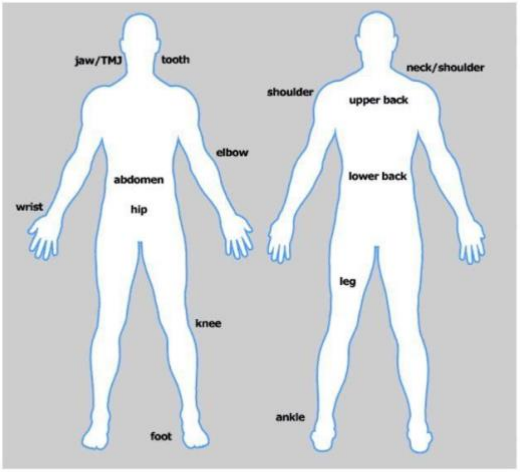
Injury history

The following section asks about injuries that you have sustained when playing or training for competitive sport (including basketball) over the **past 12 months.**

12 Have you suffered from an injury that caused you to miss at least one day of sport participation?

- ☐ Yes → Go to 13
- ☐ No → Go to 14

13 Please circle the area/s the injury occurred on the chart below, and take it to the researcher to discuss what type of injury it was.



14 Have you sustained any injuries while playing or practicing sport that you have continued to play through?

- ☐ Yes → Mark on chart in Q 13
- ☐ No → Go to Q 15

3.3.4 Definitions of Variables

The main dependent variable (outcome) in this study was whether any of the participants sustained any injuries in the previous 12 months or not. Separate analyses were conducted for ‘any injury’ and ‘lower limb injury (including hip, groin, knee, shin, hamstring, calf, and foot/ankle).

The main independent variables (explanatory) were the rating of sports specialisation (categorised as low, medium, or high) and average weekly sports participation volume. To find the participants' average weekly participation volume, data from question 10 of the survey (see Figure 1.) was used. Participation hours in sports that were played all year were added to those that were only played for either the summer or the winter season, and the average weekly participation hours throughout the 12 months were calculated and reported in hours per week. Three additional participation volume-based explanatory variables were included, all reported as “yes” or “no” depending on whether the athlete exceeded the recommendation. These were included based on commonly reported guidelines for youth sport participation and were; (i) did the athlete engage in organised sports for more hours per week than their age in years, (ii) did the athlete participate in basketball for more than 8 months in a year, and (iii) did the athlete exceed a 2:1 ratio of weekly hours of organised sport relative to free-play hours.

Finally, potential confounding independent variables (explanatory) including sex and age, were included in the multiple logistic regression analysis as these have been linked to injury risk previously. Sex was recorded as either female or male. Age was recorded as a combination of years and months and converted into a one-decimal point number that represented the athlete’s precise age at the time of the survey.

3.3.5 Data Analysis

All statistical analyses were completed using Jamovi, 3rd generation (The Jamovi Project, 2023). Descriptive statistics, including frequencies, proportions, and means (SD) are reported as appropriate for sex, age, sports participation hours, free-play hours, and sports specialisation. A one-way ANOVA was used to examine differences in sports participation and free-play hours between sports specialisation groups. Pearson's Chi-squared test of independence was used to examine differences in the frequency of sex, injury, and exceeding the recommended participation volume guidelines between specialisation groups.

Separate, multiple logistic regression analyses (adjusted for sex, age and participation hours) were conducted for each injury outcome to assess whether the sport specialisation category was associated with injury. Outcomes are presented as odds ratios and 95% confidence intervals (CI). Additionally, the same analyses were used to assess whether exceeding any of the volume-based participation recommendations was associated with injury history. The threshold for statistical significance was set at $p<0.05$.

3.4 Results

A total of 366 participants completed the questionnaire (mean ± SD age = 13.94 ± 2.16 years; 50.3% Male). A total of 380 unique injuries that resulted in at least one day away from sport over a 12-month period were reported. Fifty-four-point nine percent of players reported at least one injury, and lower limb injuries accounted for 70% (n = 267) of total injuries.

Forty-six per cent of young athletes (n = 169) were classified as highly specialised, 40% (n = 147) as moderately specialised and 14% (n = 50) as low specialised (Table 5). The mean weekly sports participation volume was 9.5 ± 4.67 hours. There was no significant difference in weekly sport participation hours ($p= 0.18$) or free-play hours ($p=0.86$) between specialisation groups (Table 4).

The proportion of participants who reported exceeding a ratio of 2:1 weekly organised sport to recreational free-play hours was 54% (n = 197), while the proportion of participants who reported that they participated in more organised sporting hours per week than their age in years was 16% (n = 58). The proportion of participants who reported playing basketball for more than 8 months per year was 88% (n= 321). Significantly more medium and high-specialised players played basketball for more than 8 months of the year compared to those who were low-specialised ($p=0.001$) (Table 4). There were no significant differences in the proportions exceeding the other two recommendations between specialisation groups.

Table 3. Total injuries by location

Injury Location	n (%)
Foot/ankle	139 (36.6%)
Knee	74 (19.5%)
Back	35 (9.2%)
Hand	33 (8.7%)
Neck/shoulders	20 (5.3%)
Calf	15 (3.9%)
Hamstring	14 (3.7%)
Head	13 (3.4%)
Hip	13 (3.4%)
Shin	9 (2.4%)
Arm	8 (2.1%)
Abdominals	4 (1.1%)
Groin	2 (0.5%)
Thigh	1 (0.3%)

Table 4. Demographics reported by specialisation category

	Specialisation Rate		
Descriptives	Low (n = 50, 13%)	Med (n = 147, 40%)	High (n = 169, 46%)
Age	13.94 ± 2.16	14.61 ± 2.01	14.44 ± 1.92
Participation Hours/Wk	9.11 ± 4.59	9.83 ± 4.77	9.7 ± 4.66
Free-Play hours	6.28 ± 12.18	5.76 ± 6.77	5.47 ± 5.92
Gender, n (%)			
Female	32 (64%)	72 (49%)	76 (45%)
Male	18 (36%)	74 (50%)	92 (54%)
Hours > Age, n (%)	9 (18%)	23 (15%)	26 (15%)
More than 8 months, n (%)	34 (68%)	132 (89%)	155 (91%)
Exceed 2:1 ratio, n (%)	27 (56%)	82 (57%)	88 (57%)
Any injury, n (%)	34 (68%)	90 (61%)	111 (66%)
Lower limb injury, n (%)	31 (62%)	75 (50%)	95 (56%)

Age, participation hours, and free-play hours are presented in mean ± standard deviation;
Hours > Age refers to those participants who reported they participate in more hours of organised sport per week than their age in years;
More than 8 months refers to those participants that played basketball for more than 8 months of the year;
Exceed 2:1 ratio refers to those participants that participate in more than twice the amount of organised training than free-play.

After adjusting for age, gender, and average weekly sport participation hours, neither medium nor highly specialised players had a significantly increased likelihood of reporting 'any injury' over a 12-month period compared to those that were categorised as low specialisation (Table 4). There was also no significant association between age or weekly hours of sports participation and the likelihood of reporting any injury. However, males had significantly higher odds of reporting any injury compared to females (OR = 2.06; CI=1.32 to 3.23).

Table 5. Association between specialisation and 'any injury'

		95% Confidence Interval		
Predictor	Odds-Ratio	Lower	Upper	p - value
Specialisation level:				
Low (reference)	-	-	-	-
Medium	0.60	0.29	1.22	0.162
High	0.74	0.36	1.49	0.398
Age	1.07	0.96	1.21	0.201
Gender:				
Female (reference)	-	-	-	-
Male	**2.06**	**1.32**	**3.23**	**0.001**
Weekly Hours of Participation	1.03	0.98	1.09	0.179

$p < 0.05$ is statistically significant (**highlighted in bold**);
Multiple logistic regression analysis. Confounding variables controlled for: average weekly participation volume, sex, and age;
Any injury includes injuries reported to the hip, groin, knee, shin, hamstring, calf, foot/ankle, head, neck/shoulders, abdominals, arm, hand, and back.

When considering lower limb injuries and again adjusting for age, sex, and average weekly sport participation, neither the medium nor highly specialised adolescents showed an increased likelihood of reporting a lower limb injury (Table 5). The medium specialisation group was significantly less likely to report a history of lower limb injury compared to the low specialisation group (OR = 0.50; CI =0.25 to 0.99). Males were significantly more likely than females to report a history of lower limb injury (OR = 1.83; CI=1.20 to 2.8). There was also a significant association between age and reporting a history of lower limb injury.

Table 6. Association between specialisation and 'lower limb injury'

		95% Confidence Interval		
Predictor	Odds-Ratio	Lower	Upper	p - value
Specialisation level:				
Low (reference)	-	-	-	-
Medium	**0.50**	**0.25**	**0.99**	**0.047**
High	0.62	0.31	1.22	0.170
Age	**1.13**	**1.01**	**1.26**	**0.026**
Gender:				
Female (reference)	-	-	-	-
Male	**1.83**	**1.19**	**2.82**	**0.006**
Weekly Hours of Participation	**1.04**	**0.99**	**1.09**	**0.055**

$p < 0.05$ is statistically significant (**highlighted in bold**);
Multiple logistic regression analysis. The reference group for this analysis was the low specialisation group and the female group. The confounding variables controlled for were weekly hours of participation, sex, and age; Lower limb injury includes any injury reported to the hip, groin, knee, shin, hamstring, calf, and foot/ankle

Before or after adjusting for sex, age, and participation hours, exceeding any of the participation volume recommendations was not significantly associated with a history of reporting ‘any injury’ or a ‘lower limb injury’ (Table 6).

Table 7. Association between exceeding volume-based recommendations and injury history over a 12-month period

Volume recommendations	Injury Type	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Participating in more average hours per week than age in years	Any Injury	0.79 (0.31 - 2.01)	0.622	0.79 (0.31 - 2.01)	0.79
	Lower Limb	1.20 (0.67 - 2.11)	1.2	0.69 (0.28 - 1.71)	0.432
Participating in the same sport for more than 8 months of the year	Any Injury	0.85 (0.43 - 1.66)	0.635	0.85 (0.43 - 1.66)	0.85
	Lower Limb	1.31 (0.70 - 2.46)	0.386	1.16 (0.61 - 2.22	0.64
Exceeding a 2:1 ratio of weekly organised sport : free-play hours	Any Injury	0.80 (0.49 - 1.31)	0.375	0.80 (0.49 - 1.31)	0.375
	Lower Limb	1.25 (0.80 - 1.92)	0.318	1.15 (0.72 - 1.84)	0.538

Univariate logistic regression (Unadjusted Odds Ratio);
Multiple logistic regression analysis (Adjusted Odds Ratio). The confounding variables controlled for were weekly hours of sports participation, age, and sex;
'Any Injury' includes any injury reported to the hip, groin, knee, shin, hamstring, calf, foot/ankle, head, neck/shoulders, abdominals, arm, hand, and back. 'Lower limb injury' includes any injury reported to the hip, groin, knee, shin, hamstring, calf, and foot/ankle.

3.5 Discussion

This study sought to explore the association between sports specialisation, participation volume, and injury history among New Zealand youth basketball players. The study addressed three primary objectives: Is there an association between participation volume and injury history?; is there an association between sport specialisation and injury history?; and is there an association between the ratio of organised basketball participation and free-play and injury history?

The prevalence of highly specialised basketballers (46%) was higher than previously reported in the only other basketball study we are aware of (Post et al., 2021). Compared to other New Zealand studies reporting on specialisation the prevalence was similar to numbers reported for football (Zoellner et al., 2022), but higher than those reported by McGowan et al. (2020) who looked at a variety of sports in New Zealand youth population.

Being categorised as high or medium specialisation did not increase the odds of reporting a history of injury in our group of 10-19-year-old New Zealand basketball players. However, the medium specialisation group had significantly lower odds of reporting a ‘lower limb injury’

compared to the low specialisation group. Additionally, exceeding any of the three participation volume recommendations analysed in this study did not show any association with a history of reporting ‘any injury’ or a ‘lower limb injury’. However, when looking at lower limb injuries only, there was a significant association between a history of reporting a lower limb injury and weekly hours of participation, age, and sex.

Our finding that being a medium or highly specialised athlete did not increase the likelihood of reporting a history of injury is contrary to the majority of previous studies (Whatman et al., 2023; Zoellner et al., 2022; Campbell et al., 2021; Post et al., 2017A; Post et al., 2017B; McGuine et al., 2017; Post et al., 2019; Jayanthi et al., 2020). Our medium- and highly specialised basketball players could likely have access to better resources such as athletic development coaches and in-season and off-season strength training programmes that could lead to a lower risk of injury. However, some studies have reported similar results, showing no increase in injury history in highly-specialised players of a similar age (McGowan et al., 2020; Meisel et al., 2021; Whatman et al., 2021). In addition, our study found that the medium-specialised group was less likely than the low-specialisation group to report a history of lower limb injuries. To our knowledge, this study is the only one to report this finding. The reason for this could be attributed to the fact that many of the medium-specialised players are participating in another sport in addition to basketball and that this diversification that experts recommend has contributed to lower rates of injuries. However, it is perhaps more likely that the medium-specialised young athletes in this group have access to better-informed coaches and resources than those that are categorised as low-specialisation. Better-informed coaches could lead to improvements in technique and sport-specific movement skills, as well as increase the likelihood of their team or coaches implementing injury prevention strategies.

Contrary to the majority of previous studies, our study did not find an association between exceeding any of the three volume-recommendations and increased odds of reporting a history of injury (Sugimoto et al., 2018; Jayanthi et al., 2015; Post et al., 2017A; Field et al., 2019; Nagano & Oyama, 2023; McGowan et al., 2020). A commonly asked question is ‘how much is too much’ when it comes to the participation volume of organised youth sport. A common guideline stated in literature is for youth athletes to not participate in more hours per week than their age in years. Our study indicated that only thirteen per cent of the participants exceeded this guideline, which is much lower than the 54% reported by Post et al. (2017A) and the 24.7% reported by Jayanthi et al. (2015). However, it is slightly higher than the 5% reported by McGowan et al. (2020). The lack of a clear association in our group may be due to the small number of players who reported participating in more hours of organised sports

than their age in years. As the youth athletes get older, they must participate in significantly more hours of organised sport each week to exceed the recommended ratio. Our study included a wide range of players from 10-19 years old, and it is likely that the older they get, the less likely they are to exceed this recommendation, as it simply becomes a time restraint to participate in more than 19 hours of organised sport in addition to other commitments. This is likely reflected in our study, where only 59 participants across all three specialisation groups reported exceeding this recommendation.

Our study also did not find any association between playing basketball for more than 8 months of the year and any increased odds of reporting a history of injury. Nearly 90% of the participants in our study exceeded this recommendation. Contrary to previous literature (McGowan et al., 2020; Post et al., 2017A; Post et al., 2019; Post et al., 2021), these youth athletes showed no increased odds of reporting a history of 'any injury' or 'lower limb injury'. Our study suggests that the majority of basketball players participate for longer than the traditional winter sports season. Unfortunately, this study did not measure the intensity of participation. The intensity of participation has previously been linked with an increased risk of reporting an injury for both male and female basketballers (Field et al., 2019). Based on the little information that exists on basketball specifically on this topic, it is possible that basketball offers a wider range of movement variety compared to sports like volleyball and tennis, and that this wider range of movement does not cause the same strain on the body as more repetitive movement sports. Several studies have reported an association between exceeding the 8-month recommendation and increased injury risk in specific sports like tennis, volleyball, and baseball (Post et al., 2017A; Jayanthi et al., 2019). A study by Post et al. (2020) found that the association between exceeding the volume recommendations and injury was much less likely in basketball players when compared to soccer and volleyball players. It is possible that these results are sport-specific, and that the nature of the sport may influence the risk of injury. Volleyball and tennis are more repetitive and limited in movement patterns compared to basketball, and as a result, they may be more susceptible to injury (especially overuse injury) with an excessive participation volume. It is likely that the increased risk in soccer is due to the total distance covered in football (Modric et al., 2019) being much greater than in basketball (Petway et al., 2020). It is also worth mentioning that although it is recognised as one of the guidelines to reduce injuries in the youth athlete population, only a limited number of previous studies suggest that participating in more than 8 months of the year is linked to an increased risk of reporting a history of injury (McGowan et al., 2020 & Post et al., 2017B). These studies did not adjust for different sports.

It is worth noting that this volume recommendation is also a part of the questions to determine sport specialisation level and that Post et al. (2021) did find that basketballers who were highly specialised showed a greater risk of reporting a basketball-related injury.

Participants exceeding a 2:1 ratio of organised weekly sport participation to recreational free-play did not exhibit significantly higher odds of reporting a history of either ‘any injury’ or ‘lower limb injury'. These findings differ from the majority of previous studies, where exceeding this ratio was linked to a significantly increased likelihood of reporting a history of injury (McGowan et al., 2020; Post et al., 2017A; Post et al., 2019). In contrast to previous results, our study suggests that recreational free-play may not offer a protective effect against the risk of injury in young New Zealand basketballers. However, it is important to note that recreational free-play appears to be on a declining trend, with some participants from this study reporting that they did not participate in any free-play in addition to their organised sports commitments. The declining trend in free-play is likely influenced by societal changes including a perceived lack of spare time due to the increased commitment to organised sport. This change in activity patterns raises concerns regarding consequences for young athletes’ risk of injury and highlights the need for more attention and research into the shifting landscape of physical activity for youth. Our study did not find any association between exceeding any of the volume recommendations and increased odds of reporting a history of injury, but over half of the participants in our study reported at least one injury in the previous 12 months. The significant number of injured basketball players reinforces the importance of injury prevention initiatives with a focus on individual sporting attributes and not generalising for the entire youth athlete population. Our study found a significant association between age, gender, weekly hours of participation volume, and increased likelihood of reporting a history of lower limb injuries. These findings suggest that future recommendations should attempt to tackle the appropriate weekly participation volume for basketball and ensure that identified gender differences are appropriately implemented in injury prevention strategies.

While our study provides some valuable insights, it's important to acknowledge its limitations. First, the surveys were completed by the players themselves, some as young as ten years old attempting to recall injuries over the past 12 months, which may have introduced some recall bias. Some of the young athletes may have unintentionally provided inaccurate information regarding their participation volume and injury history. However, by defining injuries as being severe enough to miss at least one day away from basketball and providing research assistants to aid with answering, we attempted to minimise recall bias. Another limitation is the lack of detail regarding the specific nature of the injuries, as we didn’t have specific diagnoses.

The cross-sectional design of this study is another limitation, as it is unable to infer causation. Basketball-specific prospective studies are needed to determine whether sport specialisation or exceeding volume recommendations are prospective risk factors for injury. It is also likely that our findings are specific to the New Zealand adolescent basketball population and not necessarily generalisable to other regions or sports. The lack of maturity measures in the study is another limitation. Finally, the specialisation scale used in our research, although the most commonly used in previous studies, has not been fully validated and may benefit from refinement.

3.6 Conclusion

To summarise, our study offers a unique perspective into the relationship between sport specialisation, participation volume, and injury history among 10-19-year-old New Zealand basketball players. Although we did not find a meaningful association between sport specialisation and injury history, or any significant association between exceeding volume recommendations and reporting a history of injury, this study contributes valuable data to growing evidence that suggests further attention should be focused on researching sports individually, rather than a generic approach. Our study suggests that it is highly likely that the association between sport specialisation, sports participation volume, and history of injury is highly dependent on the sport. Our study did, however, show that the medium specialised group had a lower likelihood of reporting a history of lower extremity injury compared to the low specialisation group, suggesting that perhaps as the players get more specialised in basketball, they also get access to better resources and the implementation of injury prevention strategies that may mitigate some of the risks of exceeding the volume recommendations.

Chapter 4: Discussion and Conclusion

4.1 Discussion

Youth basketball in New Zealand has seen an increase in popularity over the past two decades, with NZ secondary school participation increasing by 45% (School Sport New Zealand, n.d.) This trend is likely due to an evolving sporting landscape, especially notable among young athletes who are increasingly participating in intensive and specialised sports that may be influenced by different sociological and economic factors. Sport Specialisation has been defined as intentionally focusing on one sport at the cost of participating in other sports and has been associated with negative outcomes such as injuries and burnout. Participating in an excessive amount of organised sport is likely to reduce unstructured freeplay and could impact injury risk. Current findings on the link between sport specialisation and injury risk are conflicted, with factors like sport type, gender, and age being identified as influencing outcomes. The debate regarding the risks and rewards of adolescent sport specialisation is ongoing and to date lacks any definite answer. Current recommendations emphasise playing more than one sport, limiting sport participation volume, and balancing organised sport participation with free-play as a strategy for injury prevention.

The literature review (chapter 2) on sport specialisation and its association with injury highlighted the existence of various definitions for sport specialisation. Many studies in the review used different methods for assessing sport specialisation and the review highlighted the absence of a universally accepted method for its assessment. The commonly used three-point scale (Jayanthi et al., 2013) faced some criticism, while other studies (Miller et al., 2019) found a modified version of the three-point scale to be more valid than other methods. Some studies have suggested alternatives to the scale to make it more accurate (McGowan et al., 2020). This lack of a standardised method poses challenges to the comparison of studies and the accuracy of conclusions and may result in the misclassification of athletes. Trends in sport specialisation prevalence among young athletes found variability in specialisation rates ranging from 13% to 73% across different sports, genders, ages, and geographical locations. Differing methods for rating sport specialisation contribute to this variability. Contrary to a study by Pasulka et al. (2017) specialisation rate was higher in team sports than in individual sports,

possibly due to the varied demands of these sports. After exploring the literature on sports specialisation and its association with injuries the relationship is more complex than previously reported with conflicting findings in the literature. Some studies suggest a link (Jayanthi et al., 2020; Post et al., 2021; McGuine et al., 2017; Post et al., 2017A; Post et al., 2017B; Campbell et al., 2021; Zoellner et al., 2022; Post et al., 2021 & Whatman et al., 2023) while others did not find a significant association (Whatman et al., 2021; Weekes et al., 2019; McGowan et al., 2020 & Meisel et al., 2021). Type of injury, injury definition, participation volume, and intensity were identified as potential confounding factors.

The findings of the current study contrast the commonly held belief that being highly specialised in sports increases the likelihood of reporting a history of injury. The unexpectedly lower odds of lower limb injuries among medium-specialised athletes suggest potential mitigating factors such as well-informed coaches and diversified training regimens may contribute to reducing injury risk. This opens avenues for future research into the influence of coaching quality and resources on injury risk in specialised young athletes. This revelation encourages a re-evaluation of the presumed negative impact of sport specialisation, while also emphasising the need for complete comprehension of specialisation and its association with injury in any specific sporting context.

The literature review also examined the association between sports participation volume and associated injury risk. The majority of the studies in the review found some association between sports participation volume and reporting a history of injury. The studies reported large variations in the associations possibly due to factors such as the definition of injury and the methods for rating specialisation and measuring participation volume. Other factors that could affect the association are the type of sport and the gender proportions of the different studies. The different methods for reporting sports participation volume included weekly hours, total annual hours, days of participation, minutes per week, and training exposures per season. These differences lead to challenges in comparing studies.

Another significant limitation is the large variation in injury definition across the studies in the review. The variation in the definition is likely to impact the findings and also limit the ability to compare studies. Studies on sport participation volume recommend young athletes avoid participating in one sport for more than 8 months per year, limit weekly hours of participation to age in years and don't exceed a 2:1 ratio of organised sport to free-play (Post et al., 2017A; McGowan et al., 2020; Post et al., 2019). Exceeding sports participation volume recommendations and associated injury risk have been explored in several studies, but these

recommendations are likely, not generalisable due to a lack of robust evidence. Most studies have indicated an association, but the magnitude of the associations is varied. A prospective cohort study on elite ski racers found no significant risk (Hildebrandt et al., 2021), suggesting associations could be affected by specific sports. With varying findings reported in sports such as basketball, soccer, and volleyball, adjusting for the different sports is crucial (post et al., 2019). The lack of an association between exceeding the three common participation volume recommendations and overall injury risk in chapter 3 of this dissertation differs from established evidence and suggests that practical guidelines for youth basketball should be revisited. Guidelines should consider the individual demands of each athlete and sport rather than attempting to suit the entire young athlete population. By tailoring recommendations to the demands of each sport, the age of the participants, and the quality of available resources the effectiveness and applicability of the guidelines are likely improved.

Moreover, the observed decline in free-play participation among our study participants raises concerns about the broader implications for childhood physical activity. As structured, organised sports become more common, the potential consequences for overall physical and mental well-being need careful consideration. Practical applications should extend beyond injury prevention, encompassing a holistic approach to youth sports that supports both athletic development and overall health. Gender differences also impact the association, further complicating the generalisability of recommendations (Hall et al., 2015; Campbell et al., 2021; Jayanthi et al., 2020; Post et al., 2017B). The discrepancy in these results demonstrates the need for studies tailored to individual sports that consider the differing attributes and results of short-term changes in participation volumes Recommendations that generalise volume restrictions for the young athlete population as a whole should be approached with caution. Further discovery, including clear definitions, is essential to developing practical volume recommendations.

4.2 Limitations and Future Research Recommendations

Our study has provided valuable insights but has its limitations. One of the limitations is having to rely on participants as young as ten years old to self-report which could introduce a recall bias. Injuries were defined as those resulting in at least one day of absence from basketball and the participants were provided with assistants to support their understanding of the questionnaire to strengthen the data. The second limitation in this study is the lack of injury diagnoses which could impact the depth of the findings. Future studies would benefit from gathering more detailed information on injuries to enable better analysis of the associations.

The cross-sectional design limits our ability to establish causation and is another limitation of the study. Studies focusing on a single sport would be beneficial to enhance the understanding of the association between sport specialisation, participation volume, and injury risk. To accurately classify athletes, future studies should develop a validated method for rating sports specialisation and standardised methods to measure sports participation. Establishing clear definitions for what qualifies as a sports injury is also needed to make meaningful comparisons across studies. To be able to progress research in this area, researchers will need to collaborate to develop standardised approaches and guidelines that account for the specific sport. Short-term changes in participation volume could contribute to the varied results of injury risk and more research into how large changes in weekly participation volume could influence the prevalence of injury may contribute to the development of injury prevention measures. Our study focused specifically on basketball, but results could be impacted by variations in movement, training requirements, and intensity in different sports. The unique attributes of each sport and how they contribute to injury risk will be crucial to take into account when developing guidelines specific to any sport. Future research should create evidence-based guidelines while considering the unique factors of the sport and large weekly changes in participation.

4.3 Practical Applications

The unexpected findings in this study challenge existing knowledge, emphasising the need for tailored guidelines and a holistic understanding of factors influencing injury outcomes. The findings of this study offer quality insights for developing improved volume recommendations and to further enhance the performance and wellbeing of young New Zealand basketball players. Considering the prevalence of injuries reported through our study, injury prevention strategies should remain the priority in any recommendations. Collaboration and consistency between athletes, coaches, and parents are required to implement appropriate measures that impact positively, including a structured warm-up routine, a focus on safe and correct technique, and resistance training that is appropriate to the age group participating. In addition, with our study finding an association between weekly sport participation volume and the risk of reporting a history of lower limb injury, basketball programs should aim to develop and implement guidelines based on the appropriate weekly hours of participation

Monitoring the duration and intensity of weekly participation could contribute to minimising injury risk and preventing burnout among young athletes. The scheduling commitments of basketball could limit some young athletes' opportunities to engage in unstructured play.

Enabling young athletes to engage in play, in addition to their training schedule, can result in many benefits including the development of a diverse range of skills which in turn reduces the risk of injury and fosters holistic growth of young athletes. The results also highlight how crucial injury prevention techniques targeted at young males are, given they demonstrate a much higher likelihood of reporting a history of injury in comparison to young female athletes. Targeting education to players, coaches, and parents on the specific risk factors in young male athletes, whilst offering appropriate interventions, could result in a decrease in injury rates and contribute to a safer sporting environment for young male basketball players.

4.4 Conclusion

This dissertation offers valuable information regarding the relationships between participation volume, sport specialisation, and injury risk among New Zealand basketball players. The review of the literature suggests that there is a global trend towards more structured training and specialisation in one sport which raises concerns about injury risk.

The lack of clear definitions of sports injuries and the absence of a standardised method for categorising sports specialisation has added a level of complexity to understanding youth sports-related injuries. The lack of a standardised method for measuring participation volume further adds to this complexity. Our study found that highly specialised players did not show any increased odds of reporting a history of injury with the medium specialised group showing lower odds of reporting a history of injury compared to the low specialised group. The study did, however, find that older players and those participating in more hours of weekly sport were more likely to report a history of lower limb injuries. Males also had significantly larger odds of reporting a history of injury. Exceeding any of the three common sport participation recommendations was not associated with any history of injury in the upper or lower limbs. The unusual findings from chapter three of this dissertation highlight the need for guidelines to be specific to the individual sport and suggest that the landscape of youth sports is evolving Ongoing research will need to ensure that guidelines and recommendations are evidence-based and should prioritise the safety and wellbeing of young athletes.

The results from this study suggest that the impact of sports specialisation on injury risk is more complex than previously understood and could be influenced by factors such as coaching quality, sport-specific demands, and training diversity. Further research is necessary to respond to the evolving sporting landscape and to improve the overall wellbeing of young athletes. The different perspectives provided by this study indicate that further refinement of

guidelines is needed and that researchers are not done exploring the intricate relationship between sport specialisation and participation volume. New guidelines will need to account for the diverse factors influencing youth sports injuries. Placing this study as part of the larger context could contribute to an ongoing discussion of the role organised sports play in shaping the physical and mental wellbeing of young athletes. While injuries are an important factor, the holistic development of young athletes should be the priority and every guideline, intervention, and recommendation should keep this in mind.

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Appendices

Appendix A. Parent/Guardian Consent Form

Parent/Guardian Consent Form

For use in conjunction with either:

- an appropriate Assent Form when people under 16 years of age are participants in the research or
- a Consent Form when involving participants aged 16-20 years where their age makes them vulnerable as concerns informed or voluntary consent.

Project title: ***Injury, performance, maturation and specialisation in youth basketball***

Project Supervisor: ***Dr Chris Whatman***

Researcher: ***Jaron Kung***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 19/10/2020.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw my child/children and/or myself from the study at any time without being disadvantaged in any way, including team selection for my child.
- ○ I understand that if I withdraw my child/children and/or myself from the study then I will be offered the choice between having any data that is identifiable as belonging to my child/children and/or myself removed or allowing it to continue to be used. However, once the findings have been produced, removal of our data may not be possible.
- ○ My child is currently fully participating in training and competition for sports, however, if they are injured at the time of the study, my child may not participate in the testing but will still be offered the opportunity to partake in the survey.
- ○ I agree to my child/children taking part in this research.
- ○ I understand that my child is able to refuse to give assent to take part in this research.
- ○ I give consent for the researchers to access the data collected about me/my child by BBNZ and local associations under BBNZ.
- ○ I agree to give my height as part of the research and will leave my contact details to be contacted for consent. (please tick one): Yes ○ No ○
- ○ I wish to receive a summary of the research findings. (please tick one): Yes ○ No ○

Child/children's name/s : .....

.....

Parent/Guardian's signature: .....

Parent/Guardian's name: .....

Parent/Guardian's Contact Details (if appropriate):

.....

.....

Date:

Approved by the Auckland University of Technology Ethics Committee on 19 October 2020, AUTEC Reference number 20/46.

Note: The Participant should retain a copy of this form.

Appendix B. Assent Form

Assent Form

For completion by people aged under 16 years. This must be accompanied by a Parent/Guardian Consent Form.

Project title: ***Injury, performance, maturation and specialisation in youth basketball***

Project Supervisor: ***Dr Chris Whatman***

Researcher: ***Jaron Kung***

- ○ I have read and understood the sheet telling me what will happen in this study and why it is important.
- ○ I have been able to ask questions and to have them answered.
- ○ I understand that I can stop being part of this study whenever I want and that it is perfectly ok for me to do this.
- ○ I understand that participating in this study will not advantage me or disadvantage me at the camp, including being selected for teams.
- ○ If I stop being part of the study, I understand that then I will be offered the choice between having any information that that other people can know is about me removed or letting the researcher keep using it. I also understand that sometimes, if the results of the research have been written, some information about me may not be able to be removed.
- ○ I am currently injury-free and able to fully participate in basketball training and games, if I am injured at the time of the study I will not participate in the testing but will still be offered the opportunity to partake in the survey.
- ○ I agree to take part in this research.
- ○ I give consent for the researchers to access the data collected about me by BBNZ and local associations under BBNZ.

Participant's signature: .....

Participant's name: .....

Participant Contact Details (if appropriate):

.....

.....

.....

.....

Date:

Approved by the Auckland University of Technology Ethics Committee on 19 October 2020, AUTEC Reference number 20/46.

Note: The Participant should retain a copy of this form.

Appendix C. Consent Form 1

Consent Form

If you are 16 years and over you may fill in this form.

Project title: ***Injury, performance, maturation and specialisation in youth basketball***

Project Supervisor: ***Dr Chris Whatman***

Researcher: ***Jaron Kung***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 19/10/2020.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way. Including team selection.
- ○ I understand that if I withdraw from the study then I will be offered the choice between having any data or tissue that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- ○ I am not suffering from heart disease, high blood pressure, any respiratory condition (mild asthma excluded), any illness or injury that impairs my physical performance, or any infection.
- ○ I am currently injury-free and able to fully participate in basketball training and games, if I am injured at the time of the study I will not participate in the testing but will still be offered the opportunity to partake in the survey.
- ○ I agree to take part in this research.
- ○ I give consent for the researchers to access the data collected about me by BBNZ and local associations under BBNZ.
- ○ As part of this research, my parent's heights are needed and I agree to give my parents details to be contacted for consent. (please tick one): Yes ○ No ○
- ○ I wish to receive a summary of the research findings (please tick one): Yes ○ No ○

Participant's signature: .....

Participant's name: .....

Parents Contact Details:

.....

.....

.....

Date:

Approved by the Auckland University of Technology Ethics Committee on 19 October 2020, AUTEC Reference number 20/46.

Note: The Participant should retain a copy of this form.

Appendix D. Participant Information Sheet. Page 1 of 3

Participant Information Sheet

Date Information Sheet Produced:

19 October 2020

Project Title

Injury, performance, maturation and specialisation in youth basketball

An Invitation

Hi my name is Jaron Kung, I am a PhD student at AUT and a Junior Performance Coach for Basketball New Zealand (BBNZ) and I would like to invite you to participate in my study. Participation in this research is entirely voluntary and you are able to withdraw from the study at any time**. Your involvement in this study will not impact your selection at the National Talent/Selection Camps.** You and your parents should decide together whether or not to participate. You do not in any way have to participate and may stop being a part of this study at any time. If you agree to be a part of this study, please give your consent by signing and dating the consent form.

What is the purpose of this research?

Sport and increased levels of physical activity in youth are linked with high incidence of injuries. Childhood and adolescence is an important time to learn and develop correct movement patterns and optimal levels of physical conditioning to reduce injury risk. The current injury prevention practises in youth basketball is limited, we are not aware of what youth are doing to minimise their risk of injury. I am also interested in how growth and development in youth and whether youth are specialising in basketball early and if that may be linked to getting injured. Findings from this research will be anonymous when presented at sports science conference, submitted to a sports science journal for publishing, and when included in my PhD thesis.

How was I identified and why am I being invited to participate in this research?

You are identified as a potential participant for this research as you fit into the following categories:

- You have been invited by BBNZ to a talent/selection camp
- You have been selected by your local association to represent them
- Are between 11 and 18 years of age
- You are currently fully participating in training and competition for sports, however, if you are injured at the time of the study you may not participate in the testing but will still be offered the opportunity to partake in the survey
-

How do I agree to participate in this research?

You will receive this document with an attached Assent and Consent Form.

If you are under 16 years of age and would like to participate in this study. Your guardian will need to fill out and sign a Guardian Consent Form (see attached) and you will need to fill out and sign an Assent Form (see attached) to be collected by a research assistant.

If you are 16 years and over and would like to participate in this study. You will need to fill out and sign a Consent Form (see attached) to be collected by a research assistant.

Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you, including team selection. You are able to withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

What will happen in this research?

This research is conducted during your time at the BBNZ National Talent/Selection Camps. After online registration of the camp you will be invited to complete a voluntary survey about your sporting activities.

If you are not selected for a camp but are selected to a representative team by your local association, you will be invited to complete a voluntary survey about your sporting activities.

As part of the camp you will be put through a series of tests. These tests include:

Anthropometric measurements: Height, Weight, Standing reach, Wingspan, Hand span, Hand length & seated height.

Physical performance tests: ¾ court speed, lane agility, vertical jumps, horizontal jumps and 3 minute run.

Injury assessments: Y-balance, Landing Error Scoring System (LESS), and Isometric mid-thigh pull for strength.

Along with your child's growth measures, parent height allows us to estimate the maturational status of your child. If you do not wish to share this, or are not the biological parents of your child, or unable to provide this information, please leave this section blank. However, if you agree to share this information, please fill in your contact details at the end of the parent consent so one of our researchers can contact you in regards to collection of this information.

What are the discomforts and risks?

It is not anticipated that you will experience discomfort that would be greater than that occurring in a normal basketball session. You will most likely get tired and have some sore muscles the day after similar to a hard training session. You may be exposed to a small amount of physical risk or injury as you will be performing maximal pulling efforts against a fixed object. This should be no greater than the discomfort felt after the first basketball practice of the season. This discomfort is normal and will reduce by itself.

How will these discomforts and risks be alleviated?

Risk will be reduced as much as possible by implementing a suitable warm-up and cool-down before and after each testing session, abstaining from high intensity training in the 24 hours prior to each testing occasion, and arriving to each testing session well hydrated and having eaten at least 90 minutes prior to the start. You will also be sufficiently familiarized with all physical movements and tests. If you appear likely to injure yourself during the performance tests or through incorrect movement I will correct your technique and/or stop testing. There will be doctors and physiotherapists onsite during the camp so if any incidents or accidents occur they will be minimised or treated by a qualified practitioner.

What are the benefits?

The benefits for you being a part of this study include:

- An opportunity to participate and experience the testing that many high performance athletes do regularly where youth participants are unlikely to ever get a chance at participating in
- Being made aware of your potential risk for injury
- Being made aware of your ability to accelerate, sprint, change directions and jump
- Obtaining their own personal performance results, which may benefit their training and knowledge of the game

The findings of the proposed research will be valuable for sport coaches and athletes as well as adolescent athletic development coaches, strength and conditioning coaches and researchers.

Your participation in this project will also help me to complete my PhD qualification.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?

The data collection will be conducted by representatives of Manukau Institute of Technology (MIT) and stored on the OwnURGoal server which you will have an individual login for when you register for the camp. This will give you access to your results collected from the tests. The data will be held on a secure database which will only be accessed by approved BBNZ personnel.

Personal information held by BBNZ will not be shared with AUT and any data collected will have the player name removed and coded with a unique ID number before being shared with myself the lead researcher.

What are the costs of participating in this research?

Since this research will be during your BBNZ Camp, no additional cost or time will be needed. If you have been selected by your association then the only cost is your time to complete the survey.

What opportunity do I have to consider this invitation?

You have from the time of registration of the camp to decide whether or not you would like to participate in this study. If you have been selected by your association you have till the end of your season to complete the survey.

Will I receive feedback on the results of this research?

Yes, you will receive a summary of your results at the end of the data collection and BBNZ will provide you with the findings from the research at the end of the study. If you would like any additional information, please contact myself, the lead researcher.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr Chris Whatman

Email: chris.whatman@aut.ac.nz

Phone: + 64 9 921 9999 ext 7037

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, Dr Carina Meares, *ethics@aut.ac.nz* , (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Jaron Kung MSc. CSCS.

Email: jaron.kung@manukau.ac.nz, +64 21 1615552

Project Supervisor Contact Details:

Dr Chris Whatman Faculty of Health and Environmental Sciences, School of Sport and Recreation, AUT University

Email: chris.whatman@aut.ac.nz

Phone: *+ 64 9 921 9999 ext 7037*

Approved by the Auckland University of Technology Ethics Committee on 19 October 2020, AUTEC Reference number 20/46.