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Research Article / Araştırma Makalesi

The association between the growth spurt status of adolescent male cricket players and risk of injury during a cricket season – A prospective longitudinal cohort study

Ergen erkek kriket oyuncularında büyüme atağı durumu ile yaralanma riski arasındaki ilişki: Prospektif uzunlamasına bir kohort çalışması

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ABSTRACT

Objective: To determine the association between the growth spurt status (GSS) and injury risk in adolescent male cricket players during a six-month cricket season.

Materials and methods: Seventy-six male cricketer players (13-18 years old), participated in this prospective longitudinal cohort study. Injuries were self-reported weekly using a standardised questionnaire. GSS was calculated (Khamis-Roche Method) at the beginning, middle and end of the season as a percentage of predicted adult height (%PAH), categorising participants into pre-peak height velocity (PHV), circa-PHV, and post-PHV. Fischer exact, Mann-Whitney and t-tests calculated differences between groups. A mixed-effects Poisson regression analysis determined the association between the GSS and injury.

Results: At the beginning of the season, 61.8% (n=47) of participants were in circa-PHV and 38.2% (n=29) in post-PHV. At the end of the season, most participants were in post-PHV (n=38, 55.1%). Thirty-seven participants (48.7%) reported 60 in-season injuries, and 13.08 injuries were reported/1000 player hours. The highest percentage noted of injured participants in the middle and end of the season were in circa-PHV (66.7%, n=6) and post-PHV (62.5%, n=10), respectively. Previous injury predicted in-season injury (95%CI, p=0.034) in the univariate analysis. Participants were 1.9 times more likely to get injured if previously injured. No statistically independent relationship between GSS (%PAH) and rate of injuries was found.

Conclusions: There was no association between GSS and injury risk during a six-month cricket season. Pre-season assessment should identify previous injuries as this was a predictor of in-season injury and this data could form part of injury prevention strategies for young cricketers. Growth spurt status should not be overemphasized as a primary risk factor, clinicians and support staff should rather highlight established factors (bowling workload, technique, strength deficits). GSS could be monitored individually in at-risk players.

Keywords: *Adolescent, growth, athletic injuries, cricket sport*

ÖZ

Amaç: Ergen erkek kriket oyuncularında altı aylık bir kriket sezonu boyunca büyüme atağı durumu (BAD) ile yaralanma riski arasındaki ilişkiyi belirlemektir.

Gereç ve Yöntem: Bu prospektif uzunlamasına kohort çalışmasına 13-18 yaş arası yetmiş altı erkek kriket oyuncusu katıldı. Spor yaralanmaları, standartlaştırılmış bir anket aracılığıyla haftalık olarak kendi bildirimleriyle kaydedildi. BAD, sezonun başında, ortasında ve sonunda, öngörülen yetişkin boyunun yüzdesi (%PAH) kullanılarak (Khamis-Roche Yöntemi) hesaplandı ve katılımcılar büyüme atağı öncesi (pre-PHV), büyüme atağı sırasında (circa-PHV) ve sonrası (post-PHV) olarak kategorize edildi. Gruplar arasındaki farklar Fisher exact testi, Mann-Whitney ve t-testi ile analiz edildi. BAD ile yaralanma arasındaki ilişki, karışık etkili Poisson regresyon analizi ile değerlendirildi.

Bulgular: Sezon başında katılımcıların %61,8'i (n=47) circa-PHV, %38,2'si (n=29) post-PHV evresindeydi. Sezon sonunda çoğu katılımcı post-PHV'deydi (n=38, %55,1). Otuz yedi katılımcı (%48,7) sezon içinde toplam 60 yaralanma bildirdi ve 1000 oyuncu saati başına 13,08 yaralanma raporlandı. Sezonun ortasında ve sonunda yaralanan katılımcıların en yüksek yüzdesi sırasıyla circa-PHV (%66,7, n=6) ve post-PHV (%62,5, n=10) grubundaydı. Tek değişkenli analizde, önceki yaralanma sezon içi yaralanma için bir öngörücüydü (Güven aralığı %95, p=0.034). Daha önce yaralanma yaşamış katılımcıların yeniden yaralanma olasılığı 1,9 kat daha fazlaydı. BAD (%PAH) ile yaralanma oranı arasında istatistiksel olarak bağımsız bir ilişki bulunmadı.

Sonuç: Altı aylık bir kriket sezonu boyunca BAD ile yaralanma riski arasında bir ilişki bulunmamıştır. Sezon öncesi değerlendirmelerde, geçmiş yaralanmalar belirlenmelidir, çünkü bunlar sezon içi yaralanmaların öngörücüsü olabilir ve bu veriler genç kriketçiler için yaralanma önleme stratejilerinin bir parçası olabilir. Büyüme atağı durumu birincil risk faktörü olarak vurgulanmamalıdır; klinisyenler ve destek personeli bunun yerine yerleşik risk faktörlerine (örneğin bowling yükü, teknik, kuvvet eksiklikleri) odaklanmalıdır. BAD, risk altındaki oyuncularda bireysel olarak izlenebilir.

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Anahtar Sözcükler: Ergen, büyüme, spor yaralanmaları, kriket sporu

INTRODUCTION

Seasonal injury incidence rates for schoolboy-age cricketers in South Africa vary between 34% - according to literature reporting on a three-year investigation on elite junior cricket players (1) and a provincial tournament (2) - and 49% in a retrospective study (3). In Australia match injury incidence was reported at 3.57 per 1000 participations for an u14 cohort and 4.8 per 1000 participation for u16 players (4) . Gamage, Fortington (5)recalculated these rates based on match injuries per 100 participants and found the Sri Lankan youth cricket injury incidence rate of 130/100 match-player-days much higher compared to the Australian 7.5/100 (4), and South African 34.5/100 (1), 31.6/100 (6) and 34.2/100 (2) studies. It is, therefore, evident that injuries pose a threat to the growing adolescent cricketers globally.

Adolescents experience growth from approximately ten to twenty years old (7). Growth is a relatively predictable, stepwise process of somatic and biological maturation of physiological systems , during which anthropometrical, neuromuscular and structural changes occur (8) at different rates among individuals (7). Periods of rapid growth, i.e. growth spurts, are interspersed with periods of plateaus (9).

The maximal tempo of linear growth is known as peak height velocity (PHV) or the adolescent growth spurt. PHV for males occurs around 14 years on average, with the increase in height between seven and 12 centimetres (average nine centimetres), per year (10, 11). The GSS is classified as pre-PHV (%PAH <85%), circa-PHV (%PAH 85% - 96%), and post-PHV (%PAH >96%) (12) and is an indication of the proposed level of maturity (12).

The association between the GSS and injury risk in youth cricket has not yet been explored, but literature on growth-related injuries in competitive trampoline gymnasts (13), elite adolescent soccer players and youth athletes (14, 15) emphasises that athletes are more susceptible to injury during the period around PHV. The adolescent growth spurt is a critical period for adolescent athletes due to the impact thereof on injury risk (14)therefore, fitness and healthcare practitioners, should be managing this cohort with care. Additionally, older fast bowlers have also been identified as being at greater injury risk, often due to transitioning to senior teams and increased bowling workload according to Keylock, Alway (16). Sports clinicians should, therefore, recognise players transitioning through growth and increased workload phases and, beyond individual assessments and treatments, facilitate a holistic approach to managing these players by educating parents, coaches and other stakeholders about these injury risk factors.

Therefore, the objective of this study was to establish the association between GSS, according to %PAH, and injury risk during cricket season. Findings from this investigation could benefit the youth cricket community in informing training and competition adaptation during periods of vulnerability related to the growth spurt.

MATERIAL and METHODS

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline (17).

Study design

This was a prospective longitudinal cohort study spanning six months during the 2022-2023 school cricket season.

Study setting

This study was conducted in South Africa. The baseline questionnaire and initial measurements were conducted at the private schools' and cricket coaching academy's cricket facilities during the first two weeks of September 2022. This was the first of three measurements taken approximately two to three months apart (8). The season was divided into three phases: beginning (September-October 2022), middle (November-December 2022), and end (January-February 2023). Anthropometric measurements were taken at each phase. The middle-season measurements occurred in the last week of November 2022, and the end-season measurements took place in the last week of February 2023, extending into the first week of March 2023. Self-reported injury surveillance questionnaires were distributed to participants from the beginning of the study until the first week of March 2023, coinciding with the final cricket matches. See Figure 1.

Participants

Inclusion criteria

Male cricket players aged 13 to 18 years.

Exclusion criteria

Players with previous spinal or extremity surgery or known underlying skeletal growth abnormalities or deficiencies and those who received medical treatment for illnesses affecting normal maturation (e.g., endocrinological disease, growth hormone deficiencies) were excluded. The height of biological parents was used in the formula calculating PAH and the %PAH reached; therefore, players were excluded if these measurements were unavailable.

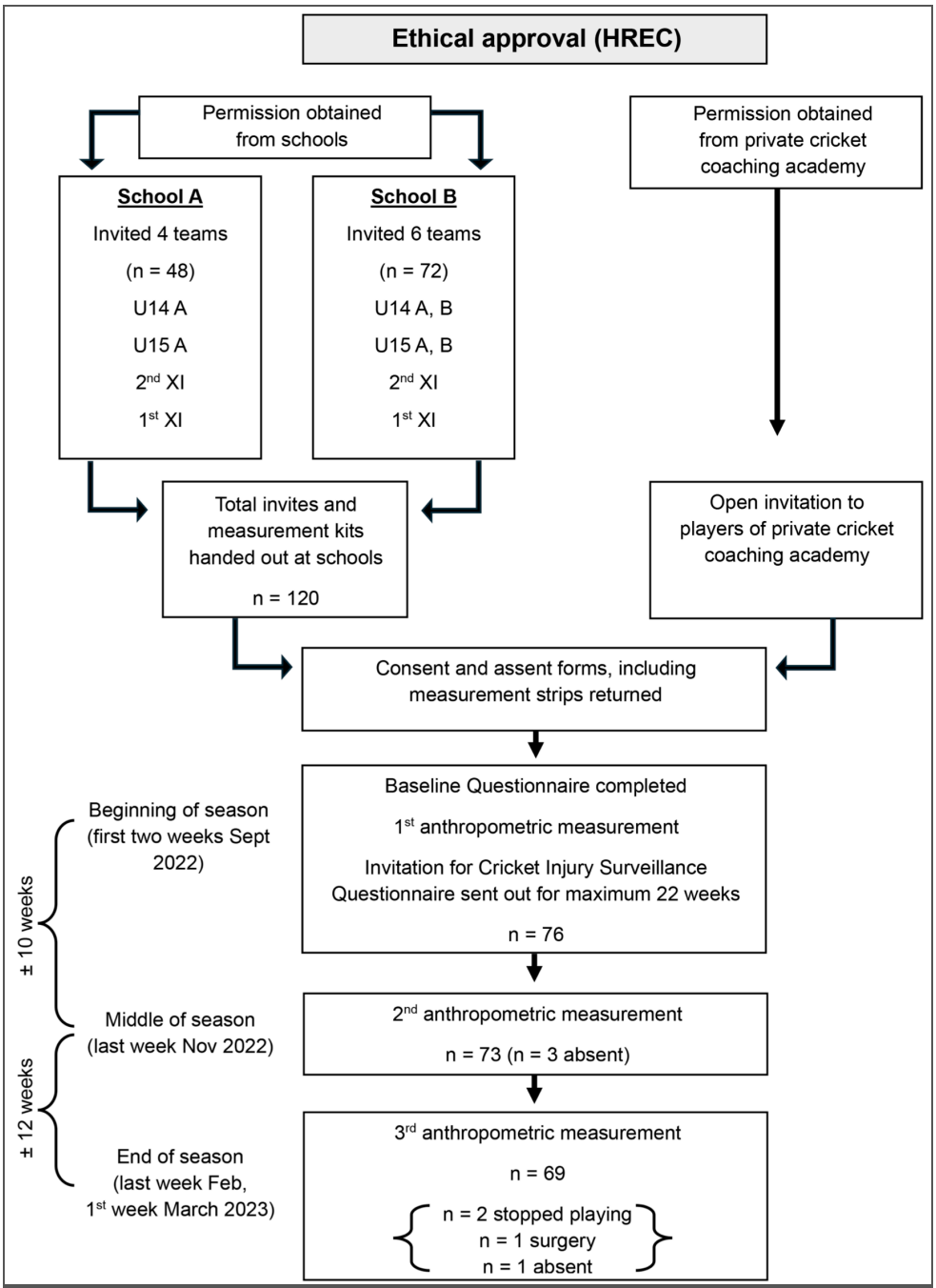

Figure 1. Flow diagram of study process and follow-up during the six-month cricket season.

Outcome measures

This study aimed to determine GSS (according to %PAH), injury rates, and the relationship between injuries and variables such as GSS (pre-, circa, and post-PHV), previous injury, level of play (school or other), team role (bowler, batter, wicketkeeper, all-rounder), batting order (top, middle, lower), type of bowler (pace or spin), bowling action (front-on, side-on, mixed), bowling order (opening and first change, second and third change, or other based on conditions), and years of bowling. The six-month season was divided into three phases: approximately ten weeks between the start and mid-season, and twelve weeks between mid-season and end-of-season measurements.

Growth spurt status

Predicted Adult Height (PAH)

Predicted adult height was calculated using the Khamis-Roche method, including the height of biological parents and participants' height and weight to the nearest 0.1 cm and 0.1 kg, respectively (18, 19).

Predicted adult height= β0 + β1 stature + β2 weight + β3 mid-parent stature

Where β1, β2 and β3 are the coefficients by which stature, weight and mid-parent stature, respectively, should be multiplied. These coefficients are applied to the formula as per the participant's chronological age (19). Skeletal age (SA) and PAH (somatic maturity) indicate growth rate. While SA is the gold standard (20), the Khamis-Roche method is non-invasive, practical, cost-effective, and calculates predicted adult height (PAH) (13, 19), determining an individual's GSS or maturity status by %PAH. Though excluding bone age, it was validated with SA (21) and is the most accurate for predicting %PAH in children aged 4-17.5 years without using skeletal age (22).

Growth spurt status classification

GSS was classified according to the percentage of PAH reached. This percentage was calculated by dividing the current height by PAH and multiplying it by 100, categorising the adolescents into pre-PHV, circa-PHV, or post-PHV (12).

%PAH= (current height)/PAH x 100

Pre- growth spurt (PHV)	Circa-growth spurt (PHV)	Post-growth spurt (PHV)
<85% of PAH	85%-96% of PAH	>96% of PAH

Injury profile

A pre-season Baseline Questionnaire and the Cricket Injury Surveillance Questionnaire were used to collect demographic data and determine the injury profiles of players during the season, respectively. These questionnaires have been used and validated in other studies (23, 24).

Baseline questionnaire

The baseline questionnaire captured age, playing level, team role, pre-season activities, and injury history. Readability, face validity, and content validity tests confirmed the questionnaires were easily understood by 15-16-year-olds, with sufficient validity and exceptional reliability. Using a two-way mixed method for absolute agreement with a 95% confidence interval (CI), the intraclass coefficient (ICC) averaged 0.986, ranging from 0.927 to 0.997.

Injury surveillance questionnaire

Injuries were self-reported with data on: injury occurrence in the past week, perceived workload/intensity changes, body region, injury nature, side, first-time, recurrent or chronic status, season, contact or non-contact, acute or gradual onset, symptom duration, occurrence during practice, match or other, injury mechanism, activity (batting, bowling, fielding or other), match format, impact on selection availability, and need for surgery. The injury surveillance questionnaire's readability score indicated it was easily understandable by a nineteen-year-old. The ICC for the baseline questionnaire averaged 0.983, with a 95% confidence interval from 0.949 to 0.974.

Definitions

Injury rates

Injury rates were calculated in multiple ways. It was expressed as the total number of injuries reported for the season, injury prevalence and injury incidence. Injury prevalence was expressed as a percentage - the total number of injured participants not available for selection divided by the total number of squad members multiplied by 100 (23-25) and injury incidence as the total amount of injuries per 1000 hours (calculating training and match hours total)(26).

Injuries

A 'player-reported injury' refers to any condition deemed an injury by the player or, for junior players without medical staff, by a parent or teacher (25). An 'acute' injury results from a single traumatic event where force exceeds tissue capacity. 'Recurrent' injuries occur to the same side, body part, and injury type as earlier in the season. 'Chronic/overuse' injuries arise from cumulative trauma due to repetitive use or stress. 'Contact' injuries involve contact with the ground, ball, or another player. Non-contact injuries occur without collision, encompassing both sudden and gradual-onset injuries not involving a collision mechanism. These operational definitions were provided in the questionnaires under the questions where terminology was used. This was done to reduce information bias, preventing participants misclassifying outcomes or returning incomplete questionnaires.

Data collection

Recruitment

Recruitment commenced once ethical approval was obtained from the Human Research Ethics Committee from a large public University of the Witwatersrand (M220439), and permission was received from the Headmasters and Directors of Cricket at the respective private schools and private cricket coaching academy. Coaches distributed invitations, including information, consent, and assent sheets for parents and players, to 120 cricketers (13-18 years old). This included ten teams with 12 players each. An open invitation was sent out to players of the academy. See Figure 1.

Height measurement of biological parents

A "home measurement kit" for biological parents' height was included in the information pack. Parents of players consenting to participate in the study returned these canvas strips to school - with their heights marked on it - as per instructions. See Figure 2.

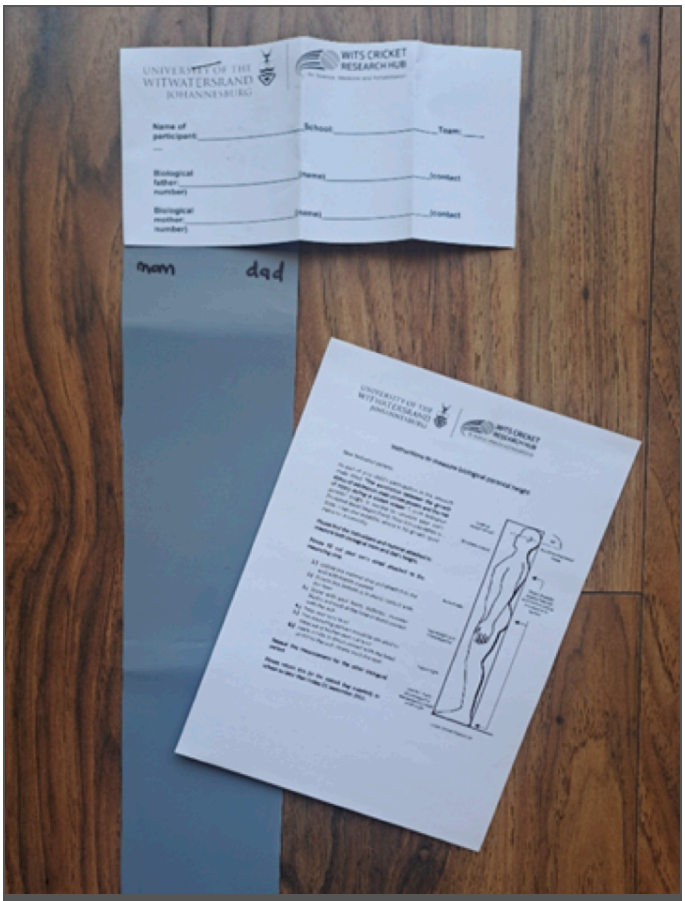

Figure 2. Home measurement kit for biological parents

Baseline questionnaire and beginning of season's anthropometric measurement

Seventy-six participants returned all required signed documents (consent and assent forms) and parental height strips, thus included in the study. Baseline questionnaires were completed at the schools' cricket facilities in early September 2022. Data (baseline, height, weight, parental height) was recorded in an electronic spreadsheet, with participants assigned study numbers and de-identified; the identifier list was stored separately to ensure confidentiality. The initial anthropometric measurements were conducted the same day. Participants arrived in teams, their personal details were verified, and they were instructed to wear only lightweight shorts for the measurements.

Height measurement

Participants were measured barefoot on a mobile stadiometer with a standing platform and horizontal head extension. Height was recorded in centimetres to the nearest millimetre (13).

Weight measurement

Participants were weighed on a calibrated scale, positioned on a solid wooden square, preventing torsion. Height and weight measurements were performed in random order.

The Cricket Injury Surveillance Questionnaire

The Cricket Injury Surveillance Questionnaire link was sent via e-mail to the included participants' parents. This invitation to report and submit injuries electronically was sent out on the same day each week for a maximum of 22 weeks up to the first week of March 2023. An auto-generated reminder was sent via email, whereafter the parent was contacted manually, per e-mail or telephonically, if no response was received. The weekly data was exported into an electronic spreadsheet and merged with the baseline and anthropometric spreadsheet.

Study size

The sample size was calculated using seasonal injury incidence at a maximum of 34% per annum (2), 17% at six months and 9% at month three. A sample of 132 participants was calculated at a significance level of 5% and power of 80. Unfortunately, due to only 120 invitations sent out by schools, and participants missing measurements or not responding to the link, a sample of convenience was used of the 76 participants returning all documentation, completing the baseline questionnaire and attending anthropometric measurements for the beginning of season.

Missing data

The percentage of missing data for the middle of season was 4% (n=3), with three participants absent for anthropometric measurements, but included in the end-of-season analysis again. Seven participants (9.2%) were excluded from the end-of-season analysis. The characteristics of the missing data participants were as follows, treated as random missing data: age (14-16 years), BMI (19.51-28.40), GSS (n=4 circa-PHV, n=3 post-PHV), level of play (n=4 school, n=3 other), role in team (n=1 batter, n=5 allrounder, n=1 bowler) injury at baseline (n=2), previous injury (n=6).

Statistical methods

STATA 18 SE (Statcorp Texas) was used for data analysis with statistical significance set at $p<0.05$. Categorical data

order, type of bowler, bowling action, bowling order) were expressed as frequencies and percentages. Continuous normally distributed data were described as means and SD, and differences between groups assessed using T-tests. The Rank sum test (Mann-Whitney) was performed on non-normally distributed and expressed as median and IQR. Injured and non-injured participants were compared per part of season using Fischer exact tests for categorical and t-tests for continuous data.

The duration of the time frame spanned across six months, during which injury surveillance questionnaires were distributed for a cumulative total of 22 weeks. Anthropometric measurements were taken at baseline (T0), approximately 10 weeks thereafter (T1) and again 12 weeks later (T2) at week 22. Outcomes were analysed longitudinally over these three time points, the beginning, middle and end of season. A univariate analysis was performed first, and the following variables were included in the multivariate analysis, following statistical significance: previous injury, role of the allrounder, %PAH, years pace bowling and part of season. Mixed effects Poisson regression analysis with random intercept were performed with a 95% CI.

RESULTS

Seventy-six participants were included at baseline in the study. The data for these participants were analysed for the beginning of the season. Three participants were excluded from the analysis for the middle of the season due to missing anthropometric measurements. They were, however, present for the last measurement and included in the end-of-season analysis. Four additional participants were excluded from analysis at the end of the season, resulting in 69 participants.

Characteristics of participants are depicted in Table 1, with injured and non-injured compared for age, height, weight and BMI. A difference was found in BMI (p=0.03) at the end of the season between injured and non-injured.

Table 1. Anthropometric characteristics of participants

Characteristics	Part of season: Beginning of season		Middle of season		End of season	
	Inj	Non-inj	Inj	Non-inj	Inj	Non-inj
Age (y) (Median and IQR)	15 [14.5-15.5]	15 [14.5-15.5]	15 [14.5-16]	15 [14.75-15.5]	15.5 [15-16.25]	15.5 [15-16]
Height (cm) (Median and IQR)	177 [173-181]	176 [170.1-181.5]	178.7 [173.9-181.3]	177.2 [171.4-182.2]	178.9 [173.9-182.2]	177.8 [172-183.3]
Weight (kg) (Median and IQR)	65.5 [57-72.1]	63.4 [58.2-70]	66.6 [59.6-73.1]	64.9 [58.8-72.8]	66.3 [57.7-73.8]	64.8 [60.8-68.5]
BMI (Mean ± SD)	21±2.4 (p=0.78)	21±2.4 (p=0.78)	21.3±1.5 (p=0.88)	21.2±2.7 (p=0.88)	22±2.7 (p=0.03)	20.5±2.4 (p=0.03)

Inj= Injured, Non-Inj= Non-injured

Growth spurt status according to %PAH (pre-, circa and post-PHV)

At the beginning of the season, 61.8% (n=47) of participants were in circa-PHV and 38.2% (n=29) in post-PHV. At the end of the season, most participants were in post-PHV (n=38, 55.1%). Of the injured participants, 66.7% (n=6) and 62.5% (n=10) were in circa-PHV and post-PHV in the middle and last part of the season respectively according to Table 2.

Table 2. Growth spurt status according to %PAH and injury during the season

Variable	Parts of season: Beginning of season participants n=76 (Total number of injuries n=27)			Middle of season participants n=73 (Total number of injuries n=9)			End of season participants n=69 (Total number of injuries n=24)		
	Total n=76	Inj part n=20	Non-inj n=56	Total part n=73	Inj part n=9	Non-inj n=64	Total n=69	Inj part n=16	Non- inj n=53
%PAH(mean±SD)	94.9±2.9 (p=0.65)	95.2±3.1 (p=0.65)	94.8±2.8 (p=0.65)	95.5±2.6 (p=0.58)	95.±2.5 (p=0.58)	95.5±2.7 (p=0.58)	96.2±2.5 (p=0.17)	97±2.1 (p=0.17)	96.±2.6 (p=0.17)
	(n/%)	**(n/%)**	**(n/%)**	**(n/%)**	**(n/%)**	**(n/%)**	**(n/%)**	**(n/%)**	**(n/%)**
Growth spurt status									
Pre-PHV (<85%) n (%)	0	0	0	0	0	0	0	0	0
Circa-PHV (85-96%) n (%)	47 (61.8) (p=1)	12 (60) (p=1)	35 (62.5) (p=1)	39 (53.4) (p=0.49)	6 (66.7) (p=0.49)	33 (51.6) (p=0.49)	31 (44.9) (p=0.57)	6 (37.5) (p=0.57)	25 (47.2) (p=0.57)
Post-PHV (>96%) n (%)	29 (38.2) (p=1)	8 (40) (p=1)	21 (37.5) (p=1)	34 (46.6) (p=0.49)	3 (33.3) (p=0.49)	31 (48.4) (p=0.49)	38 (55.1) (p=0.57)	10 (62.5) (p=0.57)	28 (52.8) (p=0.57)

Part=Participants, Inj= Injured, Non-Inj= Non-injured

Injury rates

Thirty-seven participants (48.7%) were injured during the season and 60 injuries were reported in total. Participants reported 0.79 injuries per player for the season and 13.08 injuries were reported per 1000 player hours (60 injuries per 4588 cricket exposure hours). Injury prevalence was calculated at 32.9%, as 25 of the 76 participants reported not being available for play, due to injury.

Growth spurt status according to %PAH and association with risk of injury

A mixed effects Poisson regression analysis with random intercept was performed to establish the association between risk of injury and the following variables listed: previous injury, allrounder role, GSS according to %PAH, number of years pace bowling and part of season (Table 3). No statistically significant independent relationship between the rate of injuries and GSS according to %PAH was found in the multivariate analysis when adjusting for years pace bowling, role of the allrounder, part of season and previous injury.

Table 3. Mixed effects Poisson regression analysis

	Univariate analysis			Multivariate analysis		
Variables	**IRR**	**95%CI**	**p-value**	**IRR**	**95%CI**	**p-value**
Previous injury Y/N	1.87	1.05-3.35	0.034	1.41	0.60-3.31	0.426
Role Allrounder Y/N	0.89	0.49-1.62	0.702	0.81	0.44-1.49	0.507
%PAH	1.07	0.95-1.19	0.254	1.05	0.94-1.18	0.410
Years pace bowling	1.05	0.97-1.12	0.228	1.04	0.96-1.12	0.318
Part of season-middle	0.33	0.16-0.71	0.004	0.42	0.16-1.05	0.063
Part of season-end	0.93	0.53-1.60	0.782	1.12	0.51-2.46	0.776
Participant var (_cons)				0.32	0.07-1.56	

Wald $chi^2(6)$ = 12.07 Prob> chi^2 = 0.0605 Log likelihood = -140.875

Previous injury as a predictor of injuries

In the univariate analysis (Table 3), previous injuries predicted the number of injuries. The incidence of injuries increased 1.9 times (IRR 1.87, 95%CI 1.05-3.35, p=0.34) if previous injuries were sustained.

DISCUSSION

This study, the first of its kind in youth cricket, aimed to investigate the association between GSS and injury risk in adolescent cricket. The hypothesis was that the GSS of adolescent cricket players may be associated with the risk of injury, but our findings contradicted this hypothesis.

Growth spurt status according to %PAH (pre-, circa and post-PHV)

No participants in this study were in pre-PHV, likely because the adolescent growth spurt in males typically occurs around age 14 (10, 11). The participants were older at the start of the season, suggesting they had already passed pre-PHV. Additionally, there may not have been enough late-maturing participants to classify as pre-PHV, although maturity timing was not examined.

The study did not use the maturity offset method (27) for assessing maturity status and timing due to its questionable accuracy and reliability in early and late maturing boys, despite its applicability to "average" maturing boys (28). By the end of the season, normal growth and time passage led to more participants being in post-PHV (55.1%, n=38) compared to circa-PHV (44.9%, n=31), whereas at the season's start, 61.8% (n=47) were in circa-PHV and 38.2% (n=29) were in post-PHV.

Injury rates

The injury incidence rate of 0.79 injuries per participant per season in this study, is slighter lower than the 1.3 injuries per player per season reported in a Sri Lankan study (5). The possible explanation could be that their study reported match injuries and from literature we are aware that more injuries occur during matches (2). The current study exceeded the number of injuries per player compared to that of the study on pace bowlers (0.5 injuries per player, 14 injuries/28 participants) (23), possibly due to the difference in the inclusion of all players, not only bowlers, as fielders, for instance, have been found to get more injured than bowlers during matches (5). The 13.08 injuries/ 1000 player hours compared well to the average injury incidence of 12.97 injuries/ 1000 player hours reported in a systematic review by Soomro, Strasiotto (26). Caution should be exercised when comparing these findings, however, as the minority of studies included in the meta-analysis were on junior cricketers. The injury prevalence of 32.9% compared well with the 35% in an adolescent study by Dube, Gundani and Rastogi (29).

Growth spurt status according to %PAH and association with risk of injuries

No link was found between GSS based on %PAH and injury risk during the cricket season. However, the study observed notable percentages of injured participants, holding

the season. Other studies using %PAH to indicate GSS found associations in trampolining gymnasts (13), and soccer (30). These studies identified a non-linear relationship between maturity status and injury probability, peaking at 90% and 92%-95% of %PAH. Increased non-contact and growth-related injuries in circa-PHV were also supported by soccer studies using %PAH for GSS (Monasterio et al., 2021; Johnson et al., 2020).

The second highest percentage of injured participants (62.5%, n=10) (end of season) was in post-PHV in this study. Van Der Sluis, Elferink-Gemser (31) observed a rise in traumatic injuries post-PHV, Bult, Barendrecht and Tak (32) confirmed increased injury incidence in the first six months post-PHV, and Hall, Larruskain (33)noted a higher prevalence of non-contact soft tissue injuries during this time. These studies used the maturity offset method for GSS, not %PAH, so comparisons should be cautious.

Literature on football supports the lack of association between GSS and injury risk, as studies by Light, Johnson (34) and Le Gall, Carling and Reilly (35) found no significant differences in injury occurrence, type, location, severity, or re-injury across different maturity statuses. However, these studies referred to GSS as maturity timing-categorising participants as early, on-time, or late to the expected age at PHV-rather than GSS based on %PAH in the current study. This distinction prevents direct comparison between the studies, providing only general indications of the findings.

Previous injury as a predictor of in-season injuries

The study found that previous injuries predicted in-season injuries, with participants having a 1.9 times higher risk. Olivier and Gray (36) confirmed this, showing a 1.8 times increased risk of in-season injury among professional South African players with prior lower quarter musculoskeletal injuries.

Previous injuries are frequently cited as the primary predictors of future injuries in sports such as Australian football (37). Fulton, Wright (38) systematically reviewed this topic and found that ACL injuries are linked to re-injury of the same ACL and other lower extremity injuries. Hamstring strains predict the same injury and ipsilateral knee injuries. Achilles tendon ruptures increase the risk of similar contralateral injuries, while ankle sprains are associated with recurrences on either the ipsilateral or contralateral side. It can be argued that injury resulted in changes in strength, proprioception and kinematics, potentially leading to changes in overall motor control and function.

The role of the multi-disciplinary team

The GSS was not directly associated with injury risk in this cohort; hence, clinicians should prioritise established risk factors like bowling biomechanics, intrinsic postural control, and strength and endurance deficits (39) over the adolescent growth spurt (14) in young cricketers' injury prevention. Nevertheless, monitoring it can provide valuable insights into a player's overall well-being. Assessing and managing these growth-related changes contribute to ensuring holistic athlete development and injury prevention (40) and a the multi-disciplinary team fulfils a crucial role here.

The study's limitations include the sample size and the relatively few injuries, particularly mid-season, which may have affected the ability to establish a link between GSS (%PAH) and injury. Previous injury as a predictor of in-season injury can be generalised to adolescent cricket players and may inform future youth cricket injury prevention programs.

CONCLUSION

While no association between GSS and injury risk was found, understanding where a player is in relation to their growth spurt (%PAH), may hold clinical importance in terms of overall health and specific training programmes, but should not be prioritised as a primary injury risk factor over established risk factors like bowling workload, technique and strength. The predictive value of past injuries suggests that injury surveillance data can be used by the clinicians and support staff to develop targeted injury prevention programmes and enhance player management, health and well-being.

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Ethics Committee Approval / Etik Komite Onayı

Ethical approval was received from the Human Research Ethics Committee (Medical) from the University of the Witwatersrand (ethical clearance number M220439) and performed in accordance with the Declaration of Helsinki. Written consent and assent was obtained for all participants and confidentiality was maintained by de-identifying participants and saving the identifier list separately from the data sheets.

Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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Author Contributions / Yazar Katkıları

FO was the first author and was responsible for conceptualised, methodology, formal analysis, investigation, writing the original draft, visualisation, project admin, software, validation, data curation, resources, writing (review and editing), funding acquisition. BO was responsible for conceptualisation, methodology, visualisation, writing (review and editing) and supervision. CM was responsible for conceptualisation, methodology, visualisation, writing (review and editing) and supervision.

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