

## Can Collegiate Hockey Players Accurately Predict Regional and Total Body Physiologic Changes throughout the Competitive Season?

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**Abstract:** A collegiate athlete's body composition can fluctuate due to factors such as nutrition, sleep, and training load. As changes in body composition can affect an athlete's level of performance, it may be beneficial if athlete's can accurately predict these changes throughout a season. The purpose of this study was to determine how well a group of 23 male collegiate hockey players (age = 22.44 ± 1.16 years, height = 181.30 ± 6.99 cm, weight = 86.41 ± 8.32 kg) could predict their regional and total body lean and fat tissue mass throughout a hockey season (September to March). Total body, trunk, lower body, and upper body compositional changes were measured at the beginning and at the end of the competitive season using dual energy X-Ray absorptiometry (DXA). At the end of the season, a questionnaire was completed by each participant to explore how they perceived their body composition changes (losses or gains in lean tissue and fat mass) throughout the season. Overall, players had a difficult time identifying actual changes in lean tissue and fat mass throughout the season. Upper body fat and lean tissue changes were perceived most accurately, while perceptions of body fat were related to android adiposity but not visceral adiposity. These findings suggest that some regional areas of body composition changes may happen without being noticed. For strength and conditioning coaches, if athletes are made aware of these changes before they become exaggerated, proper dietary, and training adaptations can be made to enhance performance.

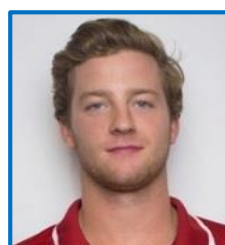
**Key Words:** Athlete perceptions, body composition, university sport, android fat, visceral fat.



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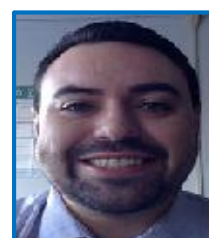
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## 1. Introduction

With an increase in speed, talent, and skill in the sport of ice hockey, athletes continually aim to improve aspects of their lives to advance performance. Many different factors such as nutrition, sleep, and training schedules impact athlete health and performance, but recently, the importance of body composition for optimal on-ice performance has been highlighted [1-3]. As physiological changes have been shown to occur throughout competitive seasons, and because of its link to on-ice performance, it's imperative for coaches to monitor possible improvements or declines in player's body compositions [3-4].

In ice hockey, assessing body composition is becoming a ubiquitous component of sport performance. Greater body fat percentage has been shown to be moderately correlated with slower skating speeds [5], lean mass has been suggested to stabilize joints and propel players across the rink [1], and gains in fat mass have been positively correlated with average shift length, shot differential, and average power-play time [3]. Professional athletes often have the luxury of multiple in-season body composition assessments to track total body, and regional fat and lean tissue masses using precise tools such as dual energy x-ray absorptiometry (DXA) scans. For elite athletes who are not yet professional (i.e., collegiate student-athletes), lack of time, and lack of availability/resources may make objective body composition assessments difficult to

obtain throughout a season. Therefore, it is important to have an understanding and appreciation for the potential fluctuations in fat and lean tissue mass which may occur throughout their respective playing seasons. For those athletes without access to routine objective measures, it is critical for them to be able to perceive possible changes throughout playing seasons and careers as accurately as possible to maximize performance, maintain a healthy lifestyle, and optimize their well-being [1, 5-6].

Prokop et al. (2015) found that in ice hockey players, from pre-season to mid-season, although some athletes predicted regional changes in fat and lean tissue, the majority of athletes were unable to detect whole body changes that were objectively identified by DXA. While only conducting the study across half the season, the study also did not consider player's perceptions of trunk fat and lean tissue mass. Within the trunk region, abdominal fat (or android fat) contains both subcutaneous fat and visceral fat [7]. Visceral adiposity surrounds internal organs, and has been directly linked to several pathological conditions including insulin resistance, certain cancers, and cardiovascular disease [7-8]. With the rise of cardiac sudden death in athletic populations [9], and its connection to obesity, it's imperative for athletes to be aware of measures of obesity, such as android and visceral adiposity. Accurately predicting android and visceral adiposity changes may allow athletes to adjust training

routines, dietary intake, and/or lifestyle habits for optimal health.

Thus, the purpose of this study was to determine if elite collegiate male hockey players could accurately predict changes in total body and regional (arms, legs, trunk) lean tissue and fat mass across an entire season. It was hypothesized that athletes may recognize changes in total body lean tissue and fat mass, but may have difficulty identifying changes in regional areas. A secondary purpose was to explore if changes in abdominal adiposity and visceral adiposity were related to perceptions of total body and trunk fat changes across a season. It was hypothesized that changes in the perception of trunk fat will be correlated with both changes in android and visceral adiposity.

## 2. Methods

### 2.1 Experimental Approach to the Problem

To determine if collegiate hockey players could accurately predict changes (lean tissue mass and fat mass) in body composition (total and regional areas), athletes completed one total body DXA scan in pre-season (September) and one post-season (March). Before the post-season scan, athletes were given a short questionnaire asking about their perceptions of potential body composition changes throughout the season (i.e., decreased noticeably, decreased slightly, stayed the same, etc.). Frequencies of correct answers were then recorded to give an idea if collegiate athletes could accurately predict regional (arms, legs, trunk) and total body changes. Additionally, Pearson correlations were used to explore if perceptions of changes in body composition regions were related to actual changes in associated regions.

### 2.2 Participants

The study consisted of twenty-three male Canadian collegiate hockey players (age =  $22.44 \pm 1.16$  years, height =  $181.30 \pm 6.99$  cm, weight =  $86.41 \pm 8.32$  kg). Players reported to the laboratory for testing in early September (pre-season) and late March (post-season) between 8 a.m. and 12 p.m.

During the first visit to the lab (pre-season), players completed one total-body DXA scan. In the second lab assessment (post-season), players completed a questionnaire as well as a follow-up DXA scan. There were no nutritional or training program requirements for the studied participants during the duration of the study; however, all players involved in the study took part in at least 75 percent of the team's on-ice practices and off-ice workouts. A typical week in the team's athletic training schedule was 3-4 on-ice practices, 2-3 off-ice workouts, and 2 games. The University Faculty of Medicine Institution Review Board approved this study, and written informed consent was obtained from the players for their participation in the study before testing began.

### 2.3 Procedures

*Anthropometric and Body Composition Assessment.* Prior to body composition assessment, players' heights and weights were recorded. Each participant's height was assessed to the nearest centimeter using a Seca 216 wall-mounted stadiometer and weight was recorded to the nearest tenth kilogram using a Seca 635 scale (Seca, Hamburg, Germany).

Measurements of full-body and regional body composition were obtained using DXA (General Electric Encore 11.20; Madison, Wis., USA) and corresponding software. The default settings of the DXA scanner's corresponding software (i.e., Lunar enCORE; Madison Wis., USA) were used to distinguish the composition profiles of the legs, arms, trunk, and total body. The DXA is considered a gold standard for assessing body composition in a research setting, and has been reported to have a total body intraclass correlation (ICC) of 0.99 and 1.00 for fat mass (%CV of 2.5) and fat-free mass (%CV of .3) while having regional ICC's between .89 and .99 (%CV between 1.3 and 4.5) [10]. Participants remained in an anatomical supine position, with their palms facing upwards for the duration of the scan [11]. The values that were recorded from the DXA scans were total body fat and lean tissue mass, fat and lean tissue in the arms, legs, trunk, android adiposity and visceral adiposity.

*Questionnaires.* Each participant's perceived changes in body composition throughout the hockey season were assessed on a 5-point scale adopted from the work of Prokop et al. (2015). To achieve a more accurate prediction on changes in body composition, the categories were modified to be more sensitive to smaller increments. Therefore, the categories were as follows: 1 = decreased noticeably >2.5% (the equivalent to losing 5 or more pounds on a 200-pound person), 2 = decreased slightly 1.5 to 2.5% (the equivalent to losing 3-5 pounds on a 200-pound person), 3 = stayed the same +/- 1.5% (the equivalent to losing or gaining 0-3 pounds on a 200-pound person), 4 = increased slightly 1.5 - 2.5% (the equivalent to gaining 3-5 pounds on a 200-pound person), 5 = increased noticeably >2.5% (= the equivalent to gaining 5 or more pounds on a 200-pound person). This scale was used by the players to indicate their perceived change in (i) total body fat mass, (ii) total body lean (muscle) tissue mass, (iii) lower body (legs) lean (muscle) tissue mass, (iv) upper body (arms) lean (muscle) tissue mass, (v) trunk (torso) lean (muscle) tissue mass, (vi) lower body (legs) fat mass, (vii) upper body (arms) fat mass, and (viii) trunk (torso) fat mass.

Android adiposity and visceral adiposity were not asked about directly in the questionnaire because the researchers felt that athletes would have difficulty distinguishing both forms of adiposity from total trunk fat.

## 2.4 Statistical Analysis

The percent change of the player's pre-season to post-season body scans were calculated using the difference between their fall (i.e., pre-season/baseline) and their spring (i.e., post-season) body composition assessments as a percentage of their pre-season values.

Change (%)

$$= \frac{\text{post-season (fat or lean) tissue mass} - \text{pre-season (fat or lean) tissue mass}}{\text{pre-season regional tissue mass}} \times 100$$

The absolute changes in android and visceral adiposity were calculated using post-season values -

pre-season values. This was done because android and visceral adiposity are relatively small parts of trunk fat mass in this population, and because both forms of adiposity were used for the correlation analysis. The categorical responses from the questionnaires were equated to help provide a better understanding of how an overall group of elite collegiate hockey players perceives the changes to their bodies during a full competitive hockey season. Pearson's r correlations were used to explore the relationship between perceptions of body composition changes and the actual fluctuations within a particular region of the body.

## 3. Results

The change in athlete's body composition from post-season to pre-season can be found in Table 1 while the frequencies of each athlete's perceived change (questionnaire) compared to their actual change (DXA) can be found in Table 2.

The majority of the players perceived gains in total body fat, and trunk fat, while losing total body lean tissue, lean tissue in the trunk, legs and arms during their season. The player's actual change was most correctly perceived in the trunk and arm regions where players correctly identified gains, losses or no change (52.18% and 50% correct respectively).

Athlete's perceived versus actual changes, as characterized by their relative change are presented in Table 3. The arms region was most accurately perceived by players, as 43.48% correctly identified arms fat and lean changes. Total body, legs, and trunk were all somewhat consistent, yet slightly less accurate.

Multiple significant correlations and trends emerged from the data; however, we chose to represent only the perceptions and actual changes that were directly related (i.e., perception of an increase in trunk fat mass, actual gain in trunk fat, or a loss in trunk lean). Arms and legs perceptions were not significant with relevant actual changes in regional tissue while perceptions of trunk fat, lean tissue, and total body fat were not correlated with absolute visceral adiposity changes. Interestingly,

those who perceived gains in trunk fat also ended the season with more trunk fat ( $r = .485, p = .019$ ), higher body fat ( $r = .574, p = .004$ ), less trunk lean tissue ( $r = -.447, p = .032$ ), less total body lean tissue ( $r = -.424, p = .044$ ), and less arm lean tissue ( $r = -.439, p = .036$ ). The remaining significant correlations can be seen in Table 4.

**Table 1.** Seasonal changes in body composition metrics in elite Canadian collegiate hockey players ( $n = 23$ ).

Change in (Post-Season – Pre-Season)	Mean $\pm$ SD	Range
Body Mass (kg)	.20 $\pm$ 2.95	-4.50 - 6.80
Total Body Fat (kg)	.60 $\pm$ 2.28	-2.40 - 6.10
Total Lean Tissue (kg)	-.61 $\pm$ 2.07	-5.51 - 2.10
Legs Lean (kg)	.09 $\pm$ 2.00	-4.68 - 3.04
Arms Lean (kg)	-.41 $\pm$ 1.5	-4.04 - 2.02
Trunk Lean (kg)	-1.29 $\pm$ 2.83	-7.39 - 2.57
Legs Fat (kg)	-.08 $\pm$ 2.04	-3.02 - 5.02
Arms Fat (kg)	.144 $\pm$ 1.64	-2.48 - 3.62
Trunk Fat (kg)	1.29 $\pm$ 2.89	-2.64 - 7.79
Android Fat (kg)	.15 $\pm$ .27	-.15 - .86
Visceral Adiposity (kg)	.06 $\pm$ .12	-.20 - .26

**Table 2.** Frequencies of perceived versus actual change (gain, loss, stayed the same) in total body, and regional tissue areas in Canadian collegiate hockey players ( $n = 23$ ).

Tissue	Season Change	Perceived Change	Actual Change	Accurate Perceptions	Accuracy for Region	
Total	Fat	Gained	17	8	8	47.83
		Same	5	11	3	
		Lost	1	4	0	
	Lean	Gained	2	1	0	39.13
		Same	3	12	1	
		Lost	18	10	8	
Legs	Fat	Gained	8	4	2	43.48
		Same	14	10	7	
		Lost	1	7	1	
	Lean	Gained	2	7	2	34.78
		Same	8	12	3	
		Lost	13	4	3	

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Trunk	Fat	Gained	18	11	11	56.52
		Same	4	7	2	
		Lost	1	5	0	
	Lean	Gained	1	4	0	47.83
		Same	8	9	3	
		Lost	15	11	8	
Arms	Fat	Gained	8	5	3	60.87
		Same	14	15	11	
		Lost	1	3	0	
	Lean	Gained	2	4	1	39.13
		Same	4	15	4	
		Lost	17	4	4	

**Table 3.** Frequencies of perceived versus actual change (gain, loss, stayed the same) categories in total body, and regional tissue areas in Canadian collegiate hockey players (n = 23).

Region	Tissue	Category	Decreased Noticeably (> 2.5%)	Decreased Slightly (1.5-2.5%)	Same ( $\pm$ 1.5%)	Increased Slightly (1.5-2.5%)	Increased Noticeably (>2.5%)	
Total	Fat	Perceived	1	0	6	9	8	
		Actual	0	4	11	5	3	
		Accurate	0	0	3	3	3	
			Predictions					
	Lean	Perceived	7	11	3	2	0	
		Actual	3	4	12	4	0	
		Accurate	2	2	1	0	0	
			Predictions					
	Legs	Fat	Perceived	0	1	14	6	2
Actual			2	5	12	1	3	
Accurate			0	1	7	0	0	
		Predictions						
		Perceived	3	10	7	2	0	
		Actual	3	1	12	6	1	
		Accurate	0	1	3	2	0	
		Predictions						

Trunk	Fat	Perceived	0	1	3	10	8	
		Actual	1	4	7	3	8	
		Accurate	0	0	2	2	5	
	Predictions							
	Lean	Perceived	4	11	7	1	0	
		Actual	7	4	8	3	1	
		Accurate	1	1	3	1	0	
	Predictions							
	Arms	Fat	Perceived	0	1	14	5	3
Actual			0	3	15	3	2	
Accurate			0	0	8	2	2	
Predictions								
Lean		Perceived	4	13	4	2	0	
		Actual	2	2	16	3	0	
		Accurate	1	2	4	1	0	
Predictions								

**Table 4.** Correlations between perceived and actual body composition changes in elite Canadian university hockey players (n = 23).

Perceived		Actual		<i>r</i>	<i>p</i>
Total Body Fat	Increase	Total Body Fat	Increase	.521	.009
Total Body Fat	Increase	Legs Fat	Increase	.554	.006
Total Body Fat	Increase	Arms Fat	Increase	.433	.039
Total Body Fat	Increase	Trunk Fat	Increase	.475	.022
Total Body Fat	Increase	Android Fat	Increase	.493	.017
Arms Fat	Increase	Arms Muscle	Decrease	-.419	.047
Trunk Fat	Increase	Arms Fat	Increase	.509	.013
Trunk Fat	Increase	Arms Muscle	Decrease	-.557	.006
Trunk Fat	Increase	Trunk Fat	Increase	.496	.016
Trunk Fat	Increase	Trunk Muscle	Decrease	-.491	.017
Trunk Fat	Increase	Android Fat	Increase	.509	.013

## 4. Discussion

The primary purpose of this study was to determine if collegiate male hockey players could accurately predict changes in total body and regional (arms, legs, trunk) lean tissue and fat mass across an entire season. Contrary to our hypothesis, our results showed that many players struggled to correctly perceive changes in total body, and regional lean and fat tissues. We posit that players are more aware about changes in fat surrounding their abdomens, and changes in lean tissue surrounding their chests and backs as these fluctuations may be more subjectively obvious than changes in other areas of the body (i.e., arms or legs).

The results of our secondary purpose revealed significant relationships between perceived gains in total body fat and trunk fat with actual absolute gains in android fat ( $p < .05$  for both correlations). Absolute changes in visceral adiposity however, were not intuitively perceived by the athletes by using total body or trunk changes in fat and lean tissue mass as possible proxies. Research investigating the tracking of athlete's perceptions of visceral adiposity across a season is scarce yet, critically important as visceral adiposity accumulation, amongst others, determines cardiovascular risk profile, and increases the susceptibility to arterial hypertension and ischaemic heart disease [8]. We suggest that because visceral adiposity is less noticeable than subcutaneous fat, athletes may find it difficult to estimate and subjectively track. Of valuable interest is that the majority of players perceived total body and regional losses in lean tissue mass, and increases in fat mass, yet, only some actually experienced those changes. Similar to Prokop et al. (2015), as many players maintained (+/- 1.5%) their lean tissue and fat masses throughout the season. Although similar in nature, our results deviate slightly from the findings of Prokop et al. (2015), possibly due to the smaller increments in tissue fluctuations (for example, maximum perception values were greater than 2.5% compared to greater than 6.5%). Additionally, taking into account recent research that demonstrates collegiate hockey player's gain fat and lose lean tissue from mid-season to post-season [4], this study took place across the entire season (and not half-

season) which also may explain some of the differences. Further, as the perception of body image is a multi-faceted component, factors such as team and personal success could have an impact on how player's perceive their body composition. To relate with the findings of Prokop et al. (2015), the team's overall win-loss record (34-10) was compared with the team's win-loss record at the mid-point of the season during the 2014-2015 campaign [13-3]. Although differences are difficult to extrapolate because of the variance in games played, both teams experienced similar success, possibly eliminating this potential confounder.

It is important to note the intimate relationship between body composition (specifically lean tissue mass), with power and strength outputs both off [2] and on the ice [5, 13]. If athletes are accurately perceiving changes in total body and regional fat and lean tissue, changes to nutrition, training status, or ergogenic aids could all be employed to maintain (or improve if needed) in-season values. Consulting nutritionists, and strength and conditioning coaches may be critical in helping athletes mitigate potential losses, and maintain pre-season lean mass values. This illustrates the need not only to preserve lean tissue mass during the season, but the need to accurately perceive fluctuations in the hopes of improving strength and on-ice performance. Our study was not without methodological considerations as our sample size was relatively small, and homogenous (only male ice hockey players between the ages of 21 and 26 years). Despite these considerations, this study was the first, to our knowledge, to track elite collegiate hockey players body perceptions of trunk changes through an entire competitive season.

## 5. Practical Applications

Collegiate coaching staffs, strength and conditioning coaches, and nutritionists should ensure that players are aware of the physiologic changes that may occur throughout a season, and that these changes may or may not be observable or accurately perceived by them, but could be simultaneously affecting performance on-ice and health off-ice. As our sample was inaccurate in tracking body



composition fluctuations, we suggest objective body composition measurements throughout the season. For those organizations or teams who may not be able to have access to DXA or BODPOD assessments, utilizing a relatively inexpensive body composition method (i.e., calipers, waist-to-hip-ratios, waist circumference) may be valuable for players to receive objective physiologic updates over short time intervals. Future research could explore body composition change perceptions, and their possible relationship to sport performance. It may be possible that those who perceive losses in fat, or gains in lean tissue may be more confident, and thus perform to their potential more so than those who perceive negative changes.

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**Competing Interests:** The author declares to have no competing interests

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