ISSN 0008-3194 (p)/ISSN 1715-6181 (e)/2022/253–264/$2.00/©JCCA 2022

Food cravings during the first week of concussion

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The brain utilizes glucose as its main source of energy. Traumatic brain injuries may alter the brain's ability to shuttle glucose effectively; therefore, the symptoms experienced may be a signal of the dysregulation. The objective of this cross-sectional study was to investigate the presence of any specific food cravings during the first week post-concussion and if the consumption of such a food decreased the symptoms of concussion. The link to the survey was posted on 4 Canadian organization websites from November 2020 to February 2021. Any individual over 18 years old who had suffered one of more concussions in the past 12 months was included. 73 females and 24 males, the majority aged 18-40 years, completed the survey. Participants with combined carbohydrate and sweet cravings reported significantly more symptoms of increased emotions (p=0.04), irritability (p=0.03), sadness (p=0.04), nervousness (p=0.03), and sleep disturbances (p=0.05) than those

Les fringales pendant la première semaine d'une commotion cérébrale

Le cerveau utilise le glucose comme principale source d'énergie. Les lésions cérébrales traumatiques peuvent altérer la capacité du cerveau à transporter le glucose de manière efficace; par conséquent, les symptômes ressentis peuvent être un signal de ce dérèglement. L'objectif de cette étude transversale était d'enquêter sur la présence de toute envie irrésistible de manger un aliment particulier pendant la première semaine suivant la commotion cérébrale et de déterminer si la consommation d'un tel aliment diminuait les symptômes de la commotion. Le lien vers l'enquête a été publié sur les sites Web de 4 organisations canadiennes de novembre 2020 à février 2021. Toute personne de plus de 18 ans ayant subi une ou plusieurs commotions cérébrales au cours des 12 derniers mois était incluse. 73 femmes et 24 hommes, âgés en majorité de 18 à 40 ans, ont répondu à l'enquête. Les participants ayant des envies combinées de glucides et de sucreries ont signalé considérablement plus de symptômes d'augmentation des émotions (p=0,04), d'irritabilité (p=0,03), de tristesse (p=0,04), de nervosité (p=0,03) et de troubles du sommeil (p=0,05) que ceux n'ayant pas ces envies.

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The authors have no disclaimers, competing interests, or sources of support or funding to report in the preparation of this manuscript.

without these cravings. Consumption of the craved food did not change the concussion symptoms.

(JCCA. 2022;66(3):253-264)

KEY WORDS: concussion, craving, food, carbohydrate, signs and symptoms

La consommation de l'aliment objet de l'envie n'a pas modifié les symptômes de la commotion cérébrale.

(JCCA. 2022;66(3):253-264)

MOTS CLÉS : commotion cérébrale, envie de manger, aliments, glucides, signes et symptômes.

Introduction

Concussions continue to be considered the most common type of brain injury. According to the Ontario government concussion guidelines, a concussion is defined as "a brain injury that cannot be seen on X-rays, CT scans or MRIs. It may affect the way a person thinks, feels and acts".[1] They further define a concussion as "a brain injury that changes how the brain functions, leading to symptoms that can be physical, cognitive, emotional/behavioural and/or related to sleep".[1] Although the research about the effects of concussions has become a priority in the health field there are still areas that need to be investigated.

It is well documented that the brain utilizes glucose as its main source of fuel, with resting brain glucose levels being approximately 3 mM.[2] The human brain depends on glucose for survival and glucose metabolism is under tight regulation considering it is critical for the brain's physiology.[3] Many brain disorders originate when there is a disruption of normal glucose metabolism and cell death.[4]

Research has shown that when at rest, the brain shuttles cerebral blood flow to the regions with the highest local glucose metabolism. All regions of the brain are continuously active; however, the areas of greatest usage will have increased blood flow. The human brain accounts for approximately 2% of the body's weight but utilizes about 20% of the total energy derived from glucose.[4] The brain has developed mechanisms by which it can detect and regulate the metabolism of glucose. An article by Rao and Oz[5] discusses gluco-sensing neurons, their presence being discovered in several regions of the brain, and how they may play a role in detecting the present glucose levels in addition to initiating responses to the glucose levels. Qin *et al*.[6] noted that a traumatic brain injury, such as a concussion, could cause a disruption of the blood brain barrier and ultimately affect the uptake and usage of glucose within the brain. This disruption of the uptake may lead to an inadequate amount of glucose being detected in the brain, potentially creating a signal to the body that the glucose requirements of the brain are not being met.[6]

Qin *et al*.[6] anesthetized male mice on which craniotomy was performed. Some mice were administered impact with a 2 ml rod at 3 m/s for 100 ms to a depth of 1 mm, which produced a moderate contusion in the right cortex causing pronounced behavioural deficits but no mortality. The glucose uptake in the brain of these mice was compared to healthy brains for vestibular motor function, water content and glucose uptake. Although this study primarily focused on the effects of an administered COG1410 solution on glucose metabolism, vestibular motor function, as well as blood brain barrier disruption, it is hard to dismiss the significant deficits that the impact produced in the traumatic brain injury group compared to the controls regarding blood brain barrier disruption as well as impaired glucose uptake.

The hypothalamus plays a significant role in energy and weight balance in the body. A condition called hypothalamic obesity is known to develop after damage to the hypothalamus from space occupying lesions or trauma.[7] Hochberg and Hochberg[7] have discussed the ventromedial hypothalamus (VMH) as playing a critical role in hyperphagia post injury. Further investigation noted that the hyperphagia was significant, however, not enough to cause obesity. The current hypothesis is that a disruption in the hormone regulation of leptin and insulin are the reason for the increased fat mass. Hyperphagia following head injury could be a potential explanation for an increased consumption of sugar; the link between leptin and insulin regulation could be a route of exploration later.

Currently, with exception to a case series by Senecal and Kazemi[8] and Germann *et al*.[9] there is no other known literature available that provides a connection between concussions in human subjects and a craving for any specific food.

Based on Senecal and Kazemi[8], Germann *et al*.[9] and the first author's experiences, most athletes with concussion expressed cravings for sweet food and that consuming such food relieved their concussion symptoms. As such, this study represents the first exploration into detecting a potential relationship between the glucose imbalance known to occur post-concussion and the clinical presentation of craving specific foods. Secondly if craved food consumption improved any of the signs and symptoms of concussion in acute phases (one to seven days after concussion). These findings would be the first evidence linking glucose dysregulation to a specific clinical presentation which can be studied as a treatment strategy in the future.

The results from this study will elucidate the phenomenon of any specific food cravings experienced after concussion. Identifying this trend will facilitate discussion about managing nutrition after concussions between doctor and patient. It could open avenues for further research for post-concussion management with nutrition. The aim of this study was to assess if subjects aged 18 years or older with a previous history of concussion in the last year experienced any specific food cravings during the first week of their concussion using an online survey tool.

Methods

A survey (Appendix 1) consisting of 13 questions was administered to eligible participants from National Sporting Organizations (NSO), Complete Concussion Management (CCM), Royal College of Chiropractic Sports Sciences Canada (RCCSS(C)) and Canadian Memorial Chiropractic College (CMCC) students from November 2020 to February 2021. The survey was sectioned into four. One section contained two questions relating to demographics, the second had two questions regarding sports, recreation and background mechanisms, and the remaining questions were sectioned regarding timeline of concussion(s) as well as presence of any food cravings. The data for this study was obtained through a survey using SurveyMonkey. The survey was initially sent to a Fellow of RCCSS(C), sports nutritionist and naturopath, a chiropractor who primarily treats patients with concussion, and a statistician for face validity. Their recommendations were incorporated into the survey.

The survey was directed to any participant (over the age of 18 years old) who has suffered one or more concussions. Further, the participants were males and females who had been diagnosed with a concussion in the last 12 months prior to the survey. Individuals who were younger than 18 or had not experienced any concussion in the last 12 months were excluded. All completed surveys were included in the sample selection. There were no physical risks to the participants of this study. All information was kept confidential. However, there were still some potential privacy concerns due to risks for data loss, and the potential for a server breach. The participation was completely voluntary, and the participants were able to withdraw from the study at any time without consequence. This study was approved by Research Ethics Board of the Canadian Memorial Chiropractic College. (REB approval number 2006B01)

The survey took less than five minutes to complete. Each question was to be answered by selecting the most appropriate response relative to the participant taking the survey. Invitation to complete the survey was posted on CCM website and Facebook page by CCM personnel. In addition, an email to request participation was sent to various NSOs, RCCSS(C) and CMCC students to either post the advertisement on their website and or Facebook page or to send to their members if possible. There was no compensation for participation in this study. The total number of emails sent to the members and/or total number of members of each organization that were able to view the advertisement on their website and/or Facebook page was not provided by the mentioned organizations. The survey software was able to inform us of the compliance of the population. The software was able to inform us if a participant completed, did not complete or withdrew from the study. Upon completion of the study, a summary of the findings will be provided to the organizations that posted and advertised the participation in the study. These organizations will post the result on their websites and or Facebook page or send it to their members.

The primary measure from the survey was the presence of food cravings during the first week post-concussion. Other measures from the survey used included the timeline of the concussion(s) in relation to the emergent cravings. These outcomes were used to assist in determining if there was a pattern that exists across the participants in the study, ultimately revealing the legitimacy of the study's hypothesis. The timeline of interest of the survey was within the first week post-concussion. The data collected involved three main areas of interest including demographics, the mechanism of the injury as well as

timeline and presence of cravings following injury. Other data analyzed included if the consumption of craved food, or lack thereof, had any effects on the participant in terms of their perceived symptoms.

Statistical analysis

All data collected in the survey were categorical variables. The sample characteristics were described using frequency and percentages. The main outcome in the study was a dichotomous variable representing cravings for carbohydrates and/or sweets – yes or no – defined for those respondents who were able to recall whether they had cravings post-concussion (n=71) and the frequency and percentage of those with cravings were used to describe this outcome. The outcome, craving for carbohydrates and/or sweets was cross-tabulated with age and sex, and p-values from an appropriate test of association (either chi-square test or Fisher's exact test dependent on cell sizes) were derived to assess for significant associations. Associations of cravings with eleven symptoms (Emotional, Irritable, Sadness, Nervous, Sleep Disturbance, Headache, Neck Pain, Concentration, Dizziness, Nausea, and Fatigue) were examined using cross-tabulations and Fisher's exact tests due to small cell counts. The statistical analysis for this study was generated using SAS software v9.4. (Copyright © 2012-2018, SAS Institute Inc., Cary, NC, USA. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.)

Results

The survey was distributed to participants aged 18 years old and above through CCM, NSOs, RCCSS and CMCC with the intent to identify those who experienced concussions in the last 12 months and if those individuals experienced specific food cravings during the first week post-concussion. There were 111 records extracted from Survey Monkey. One person entered the survey and then exited without responding to any questions, including the consent question, eight persons reported "No Concussion" in response to question 3 (see Appendix 1), and so did not complete the questionnaire. In addition, eight persons reported, "Yes" to question 3 and one reported "Prefer Not To Say", but then did not answer any further questions. Of those nine, seven were female, six were 18 to 30 years and the other two were 31 to 40, the other two were males, one 18 to 30 years and the other 31 to 40. No one reported an age outside of range. Hence there were 93 participants who responded to the survey. These 93 submissions were completed fully and appropriately and were included in the study. Table 1 illustrates the demographics of the survey respondents in general. Fifty-seven (61%) respondents were aged 18 to 30, 19 (20%) aged 31 to 40, 7 (8%) aged 41 to 50, and 10 (11%) aged 50 and above. Sixty-nine (74%) of these respondents were female while 24 (26%) were male. The reported mechanisms of concussion for all respondents were recorded in this

Table 1.
Demographics of all survey respondents (age ranges, sex, mechanism, history and timing of concussion, n=93).

	Number of respondents	% of total respondents
Age of Respondents		
18-30	57	61%
31-40	19	20%
41-50	7	8%
50+	10	11%
Sex of Respondents		
Female	69	74%
Male	24	26%
Mechanism of Concussion		
Assault	2	2%
Collision	17	18%
Fall	24	26%
MVA	20	22%
Sport	30	32%
# Concussions Past Year		
1	76	82%
2-3	12	13%
≥4	1	1%
Missing	4	4%
Most Recent Concussion		
Within last month	17	18%
2-3 months ago	16	17%
4-6 months ago	17	18%
7-12 months ago	40	43%
Missing	3	3%

Table 2.
Demographics of individuals who responded to the combined carbohydrate and sweet craving questions in the survey (n=71).

	Number of Respondents who Responded to combined carbohydrates and sweet cravings questions	% Total Respondents
Age		
18-30	39	55%
31-40	17	24%
41-50	5	7%
50+	10	14%
Sex		
Female	54	76%
Male	17	24%
Mechanism of Concussion		
Assault	1	1%
Collision	10	14%
Fall	20	28%
MVA	18	25%
Sport	22	31%

table. The most common mechanism of concussion in this group was sport-related at 30 (32%), followed by falls at 24 (26%), Motor Vehicle Accidents (MVAs) at 20 (22%), collisions at 17 (18%), and assaults at 2 (2%). Most participants (82%) reported only one concussion followed by 13% reporting two to three concussions and 1% more than four concussions in the last 12 months. Most participants (53%) reported their most recent concussion within six months and 43% within seven to twelve months prior to completing the survey.

Table 2 references the results collected from respondents who answered questions pertaining to combined carbohydrate and sweet cravings. Of the 93 individuals accounted for in the survey, 22 could not remember if they had experienced any food craving during the first week of their most recent concussion (question 8, Appendix 1) and did not respond to the following questions on craving. However, 71 responded to these questions. Of these 71 persons, 54 (76%) were female and 17 (24%) were male (four did not indicate), 39 (55%) were aged 18 to 30, 17 (24%) aged 31 to 40, five (7%) aged 41 to 50, and 10 (14%) aged 50 and above. Twenty-two (31%) reported their mechanism of concussion in this group as sport-related, 20 (28%) reported fall-related, 18 (25%) to MVA, 10 (14%) to collision, and one (1%) to assault.

Table 3.
Demographics of individuals who responded to having combined carbohydrate and sweet cravings. Information includes age ranges, sex, their respective percentage among total respondents to the combined cravings questions, and Fisher's Exact Two-Sided p-value (n=71).

	Number of Respondents who responded to combined Carb & Sweet cravings question	# With Carbohydrate & Sweets Craving	% With Carbohydrate & Sweets Craving	p-value Test of Association
	71	24	34	Chi-square test
Age				0.45
18-30	39	13	18%	
31-40	17	8	11%	
41-50	5	1	1%	
>50	10	2	3%	
				Fisher's Exact test
Sex				0.39
Female	54	20	28%	
Male	17	4	6%	

Table 4.
Number of symptoms reported by all participants (n=93).

# of Symptoms	N (Total Respondents of Study = 93)	% of total respondents
1-5	3	3%
6-10	15	16%
>10	75	81%

Table 5.
Most common to least common symptoms experienced by all participants, frequency and percentage (n=93).

Symptom	Frequency	% Of respondents
Headache	90	97%
Not feeling right	84	90%
Fatigue	82	88%
Concentration	79	85%
Pressure	76	82%
Light (sensitivity)	76	82%
Neck Pain	75	81%
Slowed Down	75	81%
Dizziness	67	72%
Emotional	66	71%
Noise (sensitivity)	64	69%
Irritable	63	68%
Nervous	62	67%
Balance	58	62%
Drowsiness	56	60%
Nausea	54	58%
Sleep (troubles with)	53	57%
Confusion	45	48%
Sadness	45	48%
Blurred Vision	42	45%
Cravings (General)	32	34%
Combined Carb & Sweet Cravings	24	26%

Further, Table 3 illustrates the demographics of the respondents who reported actually having combined carbohydrate and sweet cravings. Twenty-four respondents totaling 34% reported this specific craving (Chi-Square 0.45). Twenty individuals (28%) reported their sex as female and four (6%) reported as male (Fisher's Exact Two-Sided p-value 0.39).

Table 4 notes the number of symptoms reported by all participants. Three (3%) experienced one to five symptoms, 15 (16%) experienced six to ten symptoms, and 75 (81%) experienced 10 or more symptoms.

Table 5 documents the frequency in which symptoms were experienced by all 93 individuals who completed the survey; 90 (97%) experienced headaches, 84 (90%) experienced "not feeling right", 82 (88%) fatigue, 79 (85%) concentration, 76 (82%) pressure, 76 (82%) light sensitivity, 75 (81%) neck pain, 75 (81%) felt "slowed down", 67 (72%) dizziness, 66 (71%) emotional, 64 (69%) were sensitive to noise, 63 (68%) were irritable, 62 (67%) felt nervousness, 58 (62%) had balance issues, 56 (60%) drowsiness, 54 (58%) nausea, 53 (57%) had troubles with sleep, 45 (48%) confusion, 45 (45%) sadness, 42 (45%) blurred vision, 32 (34%) had general cravings, and 24 (26%) had combined carbohydrate and sweet cravings.

Table 6 illustrates the comparison of cravings with and without individual symptoms by means of the Fisher's Exact Two-Sided p-value. The symptoms of increased emotion (p=0.04), irritability (p=0.03), sadness (p=0.04), nervousness (p=0.03), and increased sleep disturbances (0.05) were statistically significant in individuals with carbohydrate and sweet cravings compared to those without cravings. Headache as a symptom had no evidence for an association with cravings (Fisher's Exact Two-Sided p-value = 1). Neck pain (p=0.19), concentration (p=0.74), dizziness (p=0.26), nausea (p=0.45), and fatigue (p=0.48) were not statistically significant symptoms associated with combined carbohydrate and sweet cravings.

Table 7 demonstrates whether the consumption of the craved food alleviated symptoms. There were 24 respondents who answered this question, 20 (83%) did not experience alleviation of symptoms and four (17%) did experience symptom alleviation.

Discussion

This study aimed to investigate if patients who have experienced a concussion similarly experienced any specif-

Table 6.
Comparison of cravings with and without individual symptoms including Fisher's Exact Two-Sided p-value (n=71).

Symptoms	Without Symptoms		With Symptoms		Fisher's Exact Test Two-Sided p-value
	# With Cravings / # Without Symptom	% Cravings	# With Cravings / # With Symptom	% Cravings	
Emotional	4 / 24	17%	20 / 47	43%	0.04
Irritable	4 / 25	16%	20 / 46	44%	0.03
Sadness	10 / 42	24%	14 / 29	48%	0.04
Nervous	4 / 25	16%	20 / 46	44%	0.03
Sleep disturbance	8 / 36	22%	16 / 35	46%	0.05
Headache	1 / 2	50%	23 / 69	33%	1.00
Neck Pain	2 / 13	15%	22 / 58	38%	0.19
Concentration	3 / 12	26%	21 / 59	36%	0.74
Dizziness	4 / 19	21%	20 / 52	39%	0.26
Nausea	11 / 26	39%	13 / 43	30%	0.45
Fatigue	4 / 9	44%	20 / 62	32%	0.48

ic food craving during the first week post-concussion. A survey study was conducted among individuals aged 18 years old and above who had experienced one or more concussions and had been diagnosed with a concussion in the last 12 months. There were 97 participants who responded to the survey, 93 submissions were completed fully and appropriately and were utilized in the study. The most common mechanism of concussion was sport-related at 32% with falls second most common at 26%. The higher rate of sport-related mechanism may be due to the fact that participant recruitment was facilitated by the RCCSS(C) and national sporting organizations. The fall related concussion rate could be explained by the fact that in recent years, there has been a decline in physical activity amongst adults, indicating that the younger age groups are more likely to engage in sport.[10]

Of the 93 surveys used, 71 participants completed the portion of the study pertaining to combined carbohydrate and sweet cravings following concussion. Over half of the respondents (55%) were 18 to 30-year-old range and 76% of them were female. This is in line with the literature reporting females to be more prone to concussion and lingering concussion symptoms.[11] Of the 71 participants who responded to the combined carbohydrate and sweetness cravings, 24 indicated they had experienced these specific cravings following concussion. The relationship between concussion and combined carbohydrate and sweetness cravings was not statistically significant (Chi Square analysis for age (0.45) and Fisher's Exact Two-Sided p-value for sex (0.39)). We did identify that increased emotions (43% with cravings and symptoms, p=0.04), irritability (44% with cravings and symptoms, p=0.03), sadness (48% with cravings and symptoms, p=0.04), nervousness (44% with cravings and symptoms, p=0.03), and sleep disturbances (46% with cravings and symptoms, p=0.05) were higher and statistically significant in participants with carb/sweet cravings than those without carbohydrate and sweetness cravings.

Table 7.
Result of consuming craved combined carbohydrate & sweet food on symptoms (n=24).

Relief of Symptoms after consuming craved combined carb & Sweet food	Frequency	Percent
No	20	83%
Yes	4	17%

Several studies have demonstrated that sweet cravings are associated with high levels of anxiety, guilt, sadness, loneliness, stress and irritability.[12-15] There is reported

overlap between the neural pathways that guide emotional and behavioral responses with those regulating overconsumption of highly palatable food such as sugar and carbohydrate.[16] Emotional eating has been shown to develop from a desire to mitigate stress.[16-18] Stress levels are partially regulated by the hypothalamic-pituitary-adrenal (HPA) axis.[16-18] The activity of the HPA axis has also been shown to reduce after consumption of sugar containing foods, ultimately releasing hormones that reduce the feelings of stress.[19-21] Preliminary evidence has also demonstrated that people who suffer from post-concussion syndrome have dysfunction of their HPA axis.[19-21] This has been demonstrated by measuring serum cortisol levels, which is the end product of the HPA axis.[18-19] Reduced serum cortisol was associated with more symptoms, more severe symptoms and delayed return to sport in concussed children.[17] Cortisol levels were also associated with more symptoms and delayed medical clearance in an adult sporting population.[18]

There is also the connection between cortisol, sugar cravings and females going through premenstrual syndrome (PMS). Wurtman *et al*.[21] and Brzezinski *et al*.[22] demonstrated that intake of carbohydrate was noted to increase in the luteal phase among women with premenstrual syndrome. Michener *et al*.[23] demonstrated that women with PMS had menstrual cyclic chocolate or high-sweet-fat cravings. PMS patients compared to normal women may have similar disruptions to the HPA axis, which can explain the changes in mood symptoms and sugar cravings during PMS, that are similar to those experienced in concussed patients.[24] Rabin *et al*.[24] demonstrated two HPA axis abnormalities in PMS patients that ultimately demonstrate that women with PMS might have transient or episodic disturbances of their HPA axis. These changes in women may explain why females had a higher reporting of cravings and post concussive mood disturbances, there is a possibility that the disruption to the HPA axis from hormonal changes, and from the concussion itself could be the reason females tend to be at more risk for more severe concussion symptoms and development of post concussive syndrome. However, this needs to be studied further.

Over 50% of total respondents within the 18 to 30-year-old range and over 75% in all age groups were females who reported post-concussion craving for carbohydrates or sugar. Although cravings in general were the least common symptom among all participants, it does appear that it is a commonly occurring symptom in females and in the age group of 18 to 30 years old with sport-related concussion being the most common mechanism of injury. These findings open an area for discussion around young female athletes and concussion symptoms.

It is becoming increasingly more well known that females suffer higher rates of sport-related concussion.[25-26] A systematic review and meta-analysis conducted by Brown *et al*.[27] concluded that females endure a greater severity of symptoms at baseline and post-concussion than males without significantly different symptom profiles. It has also been reported that females demonstrate worse cognitive impairment and longer recovery times.[28-29] It is thought that these differences can be explained by normal hormonal changes associated with the menstrual cycle, physiology, and cerebral blood flow.[30-32] Regarding cerebral blood flow gender differences, functional brain imaging techniques have shown that there is a robust difference between males and females in the frontal lobe area of the brain compared to parietal, temporal and occipital regions.[30] It has also been documented that there are gender related differences in the pattern of glucose metabolism, particularly involving the left frontal lobe as well as higher orbitofrontal cerebral glucose metabolism values in women.[30] Considering the frontal lobe is responsible for a multitude of cognitive processes, such as attention, memory, language, mood, and executive function, it is reasonable to believe that the differences in the frontal lobe between genders could account for the differences in post concussive symptoms.[33] As stated earlier, a healthy brain shuttles cerebral blood flow to the regions with the highest glucose metabolism.[4] With a concussion, there is thought to be a disruption of the blood brain barrier, uptake and usage of glucose within the brain.[6] This disruption of the uptake may lead to an inadequate amount of glucose being detected in the brain, potentially creating a signal to the body that the glucose requirements of the brain are not being met. This could ultimately explain why females reported a higher incidence of carbohydrate and sugar cravings post-concussion.

Those who consumed the craved food mostly reported no changes in their concussion symptoms. Based on the small sample size of respondents who answered the question of consumption of craved food, and the fact that we do not know if the remaining respondents consumed food that they were craving, it is difficult to definitively de-

termine the significance of this finding. As such further investigation with larger sample size is recommended.

Some of the limitations to the study design include a low response rate and recall bias. The proportion of subjects thought to complete the survey was estimated at 10 to 15%. This low rate of response was estimated due to the fact that the advertisement was posted on various websites and sent to the members of the organizations (CCM, NSOs, RCCSS(C) and CMCC) and it was not personally administered. The actual number of responses to the study was 97. This may reduce statistical power and generalizability of study results.

The second major limitation to this study might have been recall bias which is error in the accuracy of the information retrieved by the participants regarding events or experiences from the past. Most of the respondents (53%) indicated their most recent concussion within the last six months whereas 43% reported it to be within seven to 12 months of filling the survey. It is not certain how accurate the information provided can be. Following a literature review investigating recall bias, there was no established cut-off period determined to which a patient can still recall adequate details of an event. However, multiple studies including one authored by Barry and Tomes,[34] found that sustaining a concussion does not necessarily affect the long-term ability to recall an event as much as it affects the detail the individual provides. In addition, the number of concussions sustained did not alter the finding that both the control and concussed groups were equally able to recall the same number of autobiographical memories. Waiting until symptoms completely abated did not improve the level of detail the participants were able to provide, as the majority reported their most recent concussion occurring within a three to 13-month range. In another study by Ryan and Ruff,[35] it was reported that even patients who did not receive treatment following their concussion were seen to improve in their memory recall. For this survey, the participants' most recent concussion was anytime between the time they participated and the past year beforehand. This allowed the best opportunity to collect accurate symptom information according to the studies mentioned above.

Conclusion

Based on a small population survey of adult participants who experienced concussions less than 12 months prior to the administration of the survey, there was no statistical significance between the presence of carbohydrate or sweet cravings and concussion injury. It was identified that increased emotions, irritability, sadness, nervousness, and sleep disturbances were higher and statistically significant in participants with combined carbohydrate and sweet cravings than those without these cravings. Those who consumed the craved food mostly reported no changes in their concussion symptoms. This information, although with some limitations, may provide a basis for research into limbic patterns and glucose metabolism in individuals with head injury and post-concussion syndrome.

Acknowledgement

We would like to thank Dr. Sheilah Hogg-Johnson for her assistance with statistical analysis. We would also like to thank CCM, CMCC, RCCSS(C) and NSOs for their assistance in our data collection.

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Appendix 1.
Craving during first week of concussion questionnaire

1. What is your age?
   a. 18-30
   b. 31-40
   c. 41-50
   d. Above 50

2. What is your biological sex?
   a. Male
   b. Female

3. Have you ever been diagnosed with a concussion?
   ❒ Yes
   ❒ No

   (IF NO THE PARTICIPANT WILL BE DIRECTED TO THE CLOSING STATEMENT THANKING THEM FOR PARTICIPATION)

4. Please check off all of the following symptoms you have had with your concussion:
   a. Headache
   b. "Pressure in head"
   c. Neck Pain
   d. Nausea or vomiting
   e. Dizziness
   f. Blurred vision
   g. Balance problems
   h. Sensitivity to light
   i. Sensitivity to noise
   j. Feeling slowed down
   k. "Don't feel right"
   l. Difficulty concentrating
   m. Fatigue or low energy
   n. Confusion
   o. Drowsiness
   p. More emotional
   q. Irritability
   r. Sadness
   s. Nervous or Anxious
   t. Trouble falling asleep

5. What was the cause of the concussion?
   a. Motor Vehicle Accident
   b. Fall
   c. Sport-Related
   d. Collision with an object
   e. Other

6. If sport-related, which sport or activity were you participating in?
   a. Baseball
   b. Basketball
   c. Cycling
   d. Diving
   e. Equestrian
   f. Football
   g. Figure-skating
   h. Hockey
   i. Lacrosse
   j. Martial arts
   k. Motor Sports
   l. Rugby
   m. Running
   n. Soccer
   o. Swimming
   p. Volleyball
   q. Other (please specify)

7. How many concussions have you had in last year?
   a. 1
   b. 2-3
   c. 4-6
   d. More than 6

8. When was your most recent concussion?
   a. Within last month
   b. Within last 2-3 months
   c. Within last 4-6 months
   d. 7-12 months ago

9. Have you experienced any food cravings during the first week of your most recent concussion?
   ❒ Yes
   ❒ No
   ❒ Cannot remember

   If yes, what kind of food? (Choose as many as applies)
   i. Sour
   ii. Spicy
   iii. Salty
   iv. Sweet
   v. Protein (meat, chicken, fish, etc.)
   vi. Carbohydrates (bread, rice, pasta, chips, etc)
   vii. Fatty food
   viii. Others (please specify)

   If you answered "No" or "cannot remember" to question 9, please skip questions 10-13 and go to exit page.

10. Were/Are your symptoms of concussion (headache, dizziness, fogginess, moodiness, fatigue, etc.) alleviated or improved after consuming the craved food?

    ❒ Yes
    ❒ No
    ❒ Cannot remember

    If so which one of the craved foods? (Choose as many as applies)
    i. Sour
    ii. Spicy
    iii. Salty
    iv. Sweet
    v. Protein (meat, chicken, fish, etc.)
    vi. Carbohydrates (bread, rice, pasta, chips, etc)
    vii. Fatty food
    viii. Others (please specify)

11. Have you continued to crave after it was consumed?
    ❒ Yes
    ❒ No
    ❒ Cannot remember

12. In the case of resolution of concussion symptoms, did your cravings for this particular food continue?
    ❒ Yes
    ❒ No
    ❒ Cannot remember
    ❒ Symptoms are currently ongoing

13. In the absence of another concussion, has the cravings re-emerged after a period without the cravings?
    ❒ Yes
    ❒ No
    ❒ Cannot remember
    ❒ Symptoms are currently ongoing