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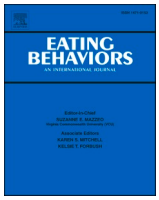

Creatine monohydrate use is prospectively associated with muscle dysmorphia symptomatology

Kyle T. Ganson [a,*], Alexander Testa [b], Jason M. Nagata [c]

[a] Factor-Inwentash Faculty of Social Work, University of Toronto, Toronto, ON, Canada
[b] Department of Management, Policy and Community Health, University of Texas Health Science Center at Houston, Houston, TX, USA
[c] Department of Pediatrics, University of California, San Francisco, San Francisco, CA, USA

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ABSTRACT

This study aimed to determine the prospective association between creatine monohydrate use and muscle dysmorphia symptomatology among adolescents and young adults in Canada. Data from 912 adolescents and young adults from the Canadian Study of Adolescent Health Behaviors were analyzed. Creatine monohydrate use in the past 12 months was assessed at Wave 1, and muscle dysmorphia symptomatology was measured using the Muscle Dysmorphic Disorder Inventory (MDDI) at Wave 1 and Wave 2. The prospective associations between creatine monohydrate use and the MDDI total score and subscale scores were determined using linear regression analyses. Regression analyses controlled for relevant demographic identifiers, prior substance use, and the corresponding Wave 1 MDDI variable. Creatine monohydrate use at Wave 1 was prospectively associated with both total muscle dysmorphia symptomatology (*B* 1.34, 95 % CI 0.27, 2.42) and greater Appearance Intolerance (*B* 0.52, 95 % CI 0.02, 1.03) at Wave 2. Importantly, these findings were independent of prior muscle dysmorphia symptomatology, lifetime anabolic-androgenic steroid use, lifetime cigarette use, and frequency of alcohol use. Creatine monohydrate is commonly used among adolescents and young adults. Findings from this study are among the first to document that creatine monohydrate use may be a risk factor for the development of muscle dysmorphia symptomatology among adolescents and young adults. Health and mental health care professionals may consider assessing for both creatine monohydrate use and muscle dysmorphia symptomatology among adolescents and young adults.

1. Introduction

Muscle dysmorphia is a complex mental health condition with symptoms focused on the preoccupation with a perceived lack of muscularity, significant drive for muscularity, and functional impairment (Grunewald & Blashill, 2021). It is common for individuals who experience muscle dysmorphia symptomatology to engage in a wide variety of behaviors in their attempt to build and maintain their musculature, including the use of muscle-building dietary supplements (Grunewald & Blashill, 2021), such as creatine monohydrate (referred to as "creatine" hereafter; Martenstyn et al., 2022). Creatine has the purported benefits of increasing muscle mass and strength and enhancing recovery (Kreider et al., 2017). Creatine use is common among adolescents and young adults, with lifetime and 12-month prevalence estimates of 15–50 % for boys and young men and 2–10 % for girls and young women (Ganson et al., 2022; Nagata, Hazzard, et al., 2022). While there is a connection between creatine use and muscle dysmorphia symptomatology, there is a dearth of research using longitudinal data focused on determining behaviors that may increase the risk of developing muscle dysmorphia symptomatology. This study aimed to determine the prospective association between creatine use and muscle dysmorphia symptomatology among adolescents and young adults.

2. Methods

Data were from the Canadian Study of Adolescent Health Behaviors (N = 912), a national, community sample of adolescents and young adults (Mage = 23.4, SD = 3.8; 57.4 % girls and young women; 62.2 % white, 3.5 % black, 17.1 % Asian, 11.0 % multi-racial, 6.2 % other race/ethnicity) in Canada. Sampling occurred via Instagram and Snapchat advertisements, without targeting specific interests or groups. Wave 1 (N = 2774) data were collected from November to December 2021.

* Corresponding author at: Factor-Inwentash Faculty of Social Work, University of Toronto, 246 Bloor Street W, Toronto, ON M5S 1V4, Canada.
E-mail address: kyle.ganson@utoronto.ca (K.T. Ganson).

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Wave 2 data were collected one year later (2022). Participants from Wave 1 who elected to participate in Wave 2 were contacted via email. The data were collected online via Qualtrics, which included various measures to prevent bot infiltration (e.g., reCAPTCHA verification, attention checks, and honeypot items; Xu et al., 2022). The Research Ethics Board at the University of Toronto (#41707) approved this study and informed consent was obtained from all participants.

2.1. Statistical analysis

Unadjusted mean differences between creatine use (any/none) in the past 12 months (assessed at Wave 1) and muscle dysmorphia symptomatology (assessed at Wave 2) were determined using independent samples *t*-tests. Adjusted linear regression analyses were conducted to determine the prospective association between creatine use (any/none) in the past 12 months (assessed at Wave 1) and muscle dysmorphia symptomatology (assessed at Wave 1 and Wave 2). Muscle dysmorphia symptomatology was measured using the Muscle Dysmorphic Disorder Inventory (MDDI; Hildebrandt et al., 2004), which is among the most widely used measures for muscle dysmorphia symptomatology (Grunewald & Blashill, 2021). The three subscales (Drive for Size, Appearance Intolerance, and Functional Impairment) and the total score were assessed for both unadjusted and adjusted analyses. Internal reliability using Cronbach's alpha was good for the MDDI total score (Wave 1: $\alpha = 0.80$; Wave 2: $\alpha = 0.79$), Drive for Size subscale (Wave 1: $\alpha = 0.87$; Wave 2: $\alpha = 0.86$), Appearance Intolerance subscale (Wave 1: $\alpha = 0.85$; Wave 2: $\alpha = 0.86$), and Functional Impairment subscale (Wave 1: $\alpha = 0.85$; Wave 2: $\alpha = 0.85$). Analyses adjusted for age, gender, race/ethnicity, sexual orientation, highest completed education, lifetime anabolic-androgenic steroid use, lifetime cigarette use, frequency of alcohol use, and the corresponding Wave 1 MDDI score. Statistical significance was defined as 2-sided $p < .05$. All analyses were conducted using StataMP 18 in 2024.

3. Results

Nearly a quarter (21.9 %) of participants reported creatine use in the past 12 months at Wave 1. At Wave 2, the mean MDDI total score was 29.6 ($SD = 7.8$), Drive for Size score was 9.8 ($SD = 4.7$), Functional Impairment score was 8.1 ($SD = 3.7$), and Appearance Intolerance score was 11.6 ($SD = 4.3$). Mean Wave 2 MDDI total score, Drive for Size score, and Functional Impairment score were significantly higher among participants who reported creatine use at Wave 1 (all $p < .001$; Fig. 1). Conversely, the mean Wave 2 MDDI Appearance Intolerance score was significantly lower among participants who reported creatine use at Wave 1 ($p < .001$).

Results from adjusted linear regression analyses revealed significant prospective associations between creatine use at Wave 1 and greater muscle dysmorphia symptomatology at Wave 2 (Table 1). Specifically, creatine use at Wave 1 was associated with a greater MDDI total score (*B* 1.34, 95 % CI 0.27, 2.42) and greater Appearance Intolerance score (*B* 0.52, 95 % CI 0.02, 1.03) at Wave 2, while adjusting for sociodemographic identifiers, lifetime anabolic-androgenic steroid use, lifetime cigarette use, frequency of alcohol use, and the corresponding Wave 1 MDDI scores.

In exploratory analyses, there were no significant prospective associations between the use of five other commonly used muscle-building dietary supplements (i.e., amino acids, pre-workout, protein bars, weight/mass gainers, and weight protein) at Wave 1 and muscle dysmorphia symptomatology at Wave 2. See Supplementary Table 1 for cross-sectional associations between creatine use at Wave 2 and muscle dysmorphia symptomatology at Wave 2.

4. Discussion

The use of creatine was significantly and prospectively associated with greater muscle dysmorphia symptomatology at one-year follow-up among a sample of Canadian adolescents and young adults. Importantly, adjusted results are independent of prior muscle dysmorphia symptomatology, as well as other substance use behaviors, including lifetime use of anabolic-androgenic steroids. These findings provide important context for understanding the potential risk factors for the development of muscle dysmorphia symptomatology, which regularly includes the

Table 1
Prospective associations between use of creatine monohydrate in the past 12 months (Wave 1) and muscle dysmorphia symptomatology (Wave 2).

	B (95 % CI)[a]	*p*
Drive for Size	0.49 (−0.05, 1.03)	0.076
Functional Impairment	0.51 (−0.02, 1.03)	0.060
Appearance Intolerance	**0.52 (0.02, 1.03)**	**0.044**
Total MDDI Score	**1.34 (0.27, 2.42)**	**0.014**

Note: Each cell represents the abbreviated outputs of four linear regression models with creatine monohydrate use at Wave 1 as the independent variable and MDDI subscale and total scores at Wave 2 as the dependent variables.
Boldface indicates statistical significance at $p < .05$.
[a] Adjusted for age, race/ethnicity, gender, sexual orientation, highest completed education, lifetime anabolic-androgenic steroid use, lifetime cigarette use, frequency of alcohol use, and corresponding Wave 1 MDDI score.

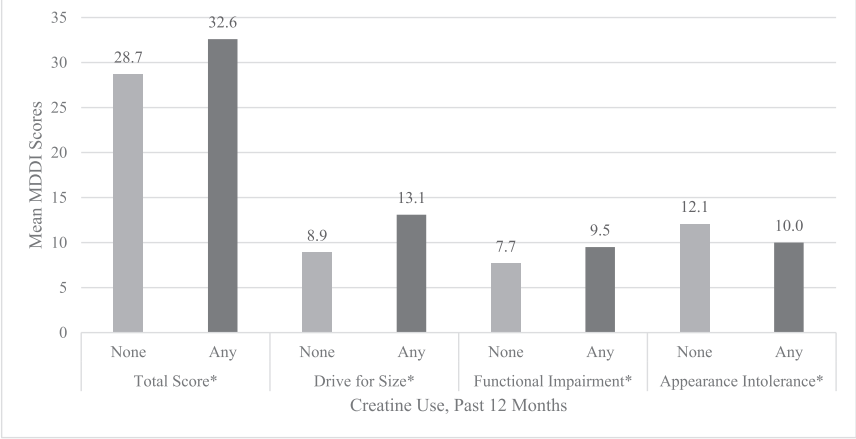

Fig. 1. Unadjusted prospective associations between creatine monohydrate use in the past 12 months (Wave 1) and muscle dysmorphia symptomatology (Wave 2).
* indicates $p < .001$.
MDDI = Muscle dysmorphic disorder inventory.

use of muscle-building dietary supplements (Martenstyn et al., 2022). The muscular and lean body ideal for boys and young men (Murray et al., 2017), and the fit and toned body ideal for girls and young women (Donovan et al., 2020), may entice adolescents and young adults to use creatine, which is widely available and easily accessible (Ganson et al., 2023) and has been shown to have some benefits for muscle growth (Antonio et al., 2021; Wu et al., 2022).

While creatine is generally considered safe to use with minimal risks to physical health (Antonio et al., 2021), health and mental health care professionals should be alerted to the finding that creatine use is associated with symptoms of muscle dysmorphia. This includes symptoms related to the drive to increase muscularity and functional impairment (from unadjusted analyses), as well as body dissatisfaction (from adjusted analyses). Health and mental health care professionals should assess and monitor for both creatine use and muscle dysmorphia symptomatology among adolescents and young adults. Indeed, recent guidance has been proposed to support health and mental health care professionals in assessing the use of muscle-building supplements, including creatine, among adolescents and young adults (Ganson & Nagata, 2024). This guidance also provides harm reduction approaches that can be implemented to mitigate potential negative effects (e.g., muscle dysmorphia) of muscle-building supplement use, including engaging in mental health treatment to address muscle dysmorphia symptomatology.

Despite the important findings of this study, there are limitations that should be noted. The data relied on self-report, which may increase the risk of reporting and recall bias. Additionally, while the MDDI has been validated among many diverse populations (see for example Compte et al., 2022; Nagata et al., 2021; Nagata, Junqueira, et al., 2022), there are no known studies that have validated this measure among Canadian adolescents and young adults, specifically, which should be considered when interpreting the findings. Thus, there is a need to validate the MDDI among Canadian adolescents and young adults. Additionally, the sampling was conducted using non-probability methods, which may reduce the generalizability of the findings, despite demographic diversity and the sample comprising participants across 12 of the 13 provinces and territories in Canada (except for Prince Edward Island). Finally, there is the possibility of unmeasured confounders. Despite these limitations, this study is among the first to document the prospective association between creatine use and muscle dysmorphia symptomatology, resulting in important implications for health and mental health professionals and underscoring the need for more research.

5. Conclusion

The results from this study are among the first to document that the use of creatine monohydrate may be a risk factor for the development of future muscle dysmorphia symptomatology. Findings underscore the need for appropriate assessment and interventions among adolescent and young adult creatine users to curtail the onset of muscle dysmorphia symptomatology. Future research is needed to corroborate these findings and explore mechanisms that underpin the connection between creatine use and muscle dysmorphia symptomatology.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eatbeh.2024.101910.

Author agreement

All authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, hasn't received prior publication, and isn't under consideration for publication elsewhere.

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CRediT authorship contribution statement

Kyle T. Ganson: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Alexander Testa:** Writing – review & editing, Conceptualization. **Jason M. Nagata:** Writing – review & editing, Conceptualization.

Declaration of competing interest

All authors report no conflicts of interests to disclose.

Data availability

Data will be made available on request.

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