

Low body fat and high cardiorespiratory fitness at the onset of the freshmen year may not protect against weight gain

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(Received 28 January 2008 – Revised 21 July 2008 – Accepted 11 August 2008 – First published online 14 November 2008)

The purpose of this study was to examine the effects of pre-university adiposity and physical fitness on changes of body weight and adiposity during the freshmen year. Twenty-nine freshmen (sixteen females and thirteen males) completed the study. Body weight and composition (dual-energy X-ray absorptiometry), waist circumference (WC), energy intake (7 d food diary) and activity-related energy expenditure (accelerometry) were measured in September, December and at the end of March. Peak oxygen uptake ($V_{O_{2peak}}$) was assessed at baseline only. Significant increases in body weight (1.9 (SD 2.0) kg, $P < 0.05$), BMI (0.6 (SD 0.7) kg/m², $P < 0.05$), WC (2.7 (SD 3.0) cm, $P < 0.05$) and % body fat (BF) (3.1 (SD 2.3) %, $P < 0.01$) were noted in males, especially over the course of the first semester. No significant changes were observed in females. Results from correlation analyses showed that, baseline %BF was negatively associated with changes in body weight ($r = -0.53$, $P < 0.01$) and %BF ($r = -0.41$, $P < 0.05$) over the academic year. Baseline %BF predicted 27 % ($P < 0.05$) of the change in weight. Alcohol intake explained 34 % ($P < 0.01$) and 17 % ($P < 0.05$) of the changes in WC and %BF, respectively. The change in body weight and %BF were also positively associated with baseline $V_{O_{2peak}}$ ($r = 0.51$, $P < 0.01$; $r = 0.48$, $P < 0.01$, respectively) while dietary restraint was negatively related to the changes in %BF ($r = -0.43$, $P < 0.05$). In summary, lower pre-university adiposity, higher $V_{O_{2peak}}$ and higher alcohol intake are associated with greater changes in adiposity and body weight during the freshmen year.

Freshmen: Body composition: Adiposity: Physical activity: Alcohol

University students are believed to be likely to gain 6.8 kg (15 pounds) in their freshmen year (the 'Freshmen 15'). In reality, the freshmen weight gain has been reported to vary from 1.1⁽¹⁾ to 2.5 kg⁽²⁾, with a great proportion of the weight gain occurring over the first semester (1.4–1.9 kg)^(3,4), whilst no sex differences in the changes in body weight have been reported^(2,4–7). The evaluation of body composition performed in some of these studies, using either bioelectrical impedance analysis^(3,7) or dual-energy X-ray absorptiometry⁽⁸⁾, also revealed an increase in percentage body fat (%BF), with one study reporting an increase in central adiposity over the freshmen year⁽⁸⁾.

Levitsky *et al.*⁽⁴⁾ found that weight gain was mostly associated with the consumption of high-fat foods (12%), the number of evening snacks (12%), and by eating at all-you-can-eat facilities for breakfast (10%) and lunch (10%). There is also evidence of a high prevalence of physical inactivity among university students^(9–13), but more relevant to the present study is the decrease in total physical activity⁽¹⁴⁾ and aerobic exercise during the first two years of university⁽²⁾. In fact, previous results support that individuals who display higher fat mass and lower physical activity level at the onset of the freshmen year, also gain more body weight during their first year⁽⁸⁾. However, to our knowledge no study has used direct measures of physical activity in order to determine the impact of the latter on the changes of adiposity that occur during the freshmen year.

Based on available literature and using precise assessments of adiposity and physical activity, we tested three hypotheses. We hypothesized that: (1) higher pre-university body weight and adiposity (dual-energy X-ray absorptiometry) would be associated with greater gains in body weight and adiposity over the freshmen year; and (2) that higher pre-university physical activity energy expenditure (accelerometry) and cardiorespiratory fitness ($V_{O_{2max}}$) would be associated with lesser changes in adiposity over the freshmen year. We also hypothesized that changes in adiposity would be independent of sex. Finally, we explored possible predictors of changes in adiposity such as socio-demographic variables and eating behaviour (Three-Factor Eating Questionnaire).

Methods

Participants

Thirty-three freshmen students were recruited from the University of Ottawa through advertisements (i.e. posters and mail) and from a stand set up at the University Center to inform students about the study. Four freshmen dropped out due to time constraints. Twenty-nine freshmen (sixteen females and thirteen males) thus completed the study. Their characteristics are presented in Table 1. The freshmen were predominantly Caucasians ($n = 27$), with two students classified

Abbreviations: $V_{O_{2peak}}$, peak oxygen uptake; WC, waist circumference; %BF, percentage body fat.

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as other ethnicity. Twelve were in the Faculty of Arts, ten in Social Sciences and seven in Health Sciences. Participants were included if they were 18 years or older, attending their first year at university, currently living in residence, previously lived at home, body weight did not vary more than 2 kg in the last 6 months, apparently healthy, non-smokers, not taking medications that could impact on energy intake and expenditure, did not diet during the previous 6 months, and were not pregnant or intending to become pregnant in the next 7 months. Those taking oral contraception were allowed to participate in the study on condition that they had been doing so for more than 6 months. We selected a sample of weight-stable participants to reduce the probability of observing changes in weight and adiposity that would have been due to factors other than the first-time exposure to the university environment. Ethical approval was granted by the University of Ottawa Research Ethics Committee and all participants gave their written consent.

Design and procedure

Participants were recruited on the university campus over a 2-week period in late August/early September 2006. At that time, participants met the researchers for one screening session on campus. Thereafter, participants visited the laboratory on three separate occasions, in the second and third week of September and the first 2 weeks of December 2006, and the last week of March and first week of April 2007. All three periods of testing lasted 2 weeks. Measurements were taken as early as possible in September and close to the Christmas break and the end of the second semester without overlapping with end-of-term examination periods. During the September session, participants filled out the Three-Factor Eating Questionnaire, and their weight and height, waist circumference (WC) and body composition were measured. A peak oxygen uptake ($V_{O_{2peak}}$) test was also performed. The two subsequent testing sessions (December and April) included measures of body weight, WC and body composition. At the end of each of the three testing periods participants were instructed to complete a 7 d food diary and asked to concurrently wear an accelerometer for 7 d. The same researcher performed the measurements at each of the three time-points.

Anthropometric measures

Body weight and height (BWB-800AS digital scale and HR-100 height rod; Tanita Corporation of America Inc.) were measured 2 h after a light meal while subjects wore a hospital gown. A conventional measuring tape abiding to Canadian Society for Exercise Physiology standards was used to measure WC. An average of two WC measurements was taken. Body composition was measured using dual-energy X-ray absorptiometry (Lunar Prodigy, GE Medical System). CV and correlation coefficient for %BF measured in twelve subjects tested in our laboratory were 1.8 % and r 0.99, respectively.

Peak oxygen uptake measurement

Participants were asked not to eat or have coffee for 2 h before the test, and not to consume alcoholic beverages or exercise for the 6 h before. A high ramped protocol with a consistent

Table 1. Female (n 16) and male (n 13) freshmen anthropometric measurements, Three-Factor Eating Questionnaire (TFEQ) scores and peak oxygen uptake ($V_{O_{2peak}}$) (Mean values and standard deviations)

	September		December		March		Time × sex, P value
	Female	Male	Female	Male	Female	Male	
	Mean	SD	Mean	SD	Mean	SD	Time, P value
Age (years)	18.4	0.7	18.2	0.4			
Height (cm)	165.4	7.6	179.2	6.1			
Body weight (kg)	58.2	10.4	74.6	11.9	58.1	10.2	0.03*
BMI (kg/m ²)	21.2	2.9	23.2	2.8	21.2	3.0	0.04*
WC (cm)	71.8	8.6	77.4	8.7	72.4	8.9	0.01**
%BF	27.7	7.3	16.1	7.2	27.5	7.3	0.01**
Fat mass (kg)	16.5	7.3	12.7	8.2	16.5	7.2	0.01**
Fat-free mass (kg)	41.1	4.6	62.1	5.4	41.1	4.7	0.28
TFEQ score							
Restraint	7.8	4.3	4.1	3.3			
Disinhibition	5.4	3.1	4.5	2.1			
Hunger	5.8	3.2	6.5	3.3			
$V_{O_{2peak}}$ (ml/kg per min)	41.8	5.1	57.4	6.4	41.1	4.7	0.03*

WC, waist circumference; %BF, percentage body fat. * $P < 0.05$, ** $P < 0.01$.

and continuous increase in speed and grade was used to measure $V_{O_{2max}}$. The initial speed was 2.6 km/h at 5 % gradient (3.3 metabolic equivalents). Speed and gradient progressively increased every 30, 40 or 60 s to reach a maximum of 9.6 km/h at 22 % gradient (19.2 metabolic equivalents) by the twenty-fifth stage (15 min). At least two of the following criteria were used to determine whether $V_{O_{2max}}$ was reached: (1) no further increase in oxygen uptake or an increase ≤ 150 ml/min with an increase in workload; (2) $RQ \geq 1.1$; and (3) a heart rate equal to or greater than the predicted maximum heart rate ($220 - \text{age}$). Some subjects did not achieve a plateau of O_2 consumption. For this reason, $V_{O_{2peak}}$ will be used henceforth. Analysers were calibrated before every test to further ensure the reliability of the measurement. This measurement was conducted during the September session only.

Energy intake

Average daily energy intake was measured using a 7 d food diary. Participants recorded all dietary intake including beverages and the respective quantity consumed. A guide sheet on portions for different foods and a sample diary for a day were attached with the food diary for guidance. Nutritional data were analysed using the computer program Food Processor SQL, V 9.6.2 (ESHS Research, Salem, OR, USA).

Accelerometry

Activity-related energy expenditure was examined using accelerometry (Actical-Mini Mitter Co. Inc., Bend, OR, USA). Participants wore the accelerometers upon waking up and took it off just before going to bed for a 7 d period. Such duration was chosen as it is estimated to result in 90 % reliability for the measurement of physical activity in both males and females⁽¹⁵⁾. The accelerometer was worn at lower back level since this was evaluated as the best predictor of energy expenditure (r 0.92–0.97), compared to lower leg/foot, upper leg, head and trunk, lower arm/hand, and upper arm⁽¹⁶⁾.

Socio-demographic questionnaire

A socio-demographic questionnaire was used to collect information pertaining to the participants' place of residence prior to attending university residence (urban, rural or other), the type of residence they lived in (apartment style, shared room, etc.), the number of televisions available, their Faculty (Arts, Social Sciences or Health Sciences), as well as their income and their parents' income, and whether they subscribed to a university meal plan to eat at the cafeteria or not.

Eating behaviour

The Three-Factor Eating Questionnaire by Stunkard, Messick⁽¹⁷⁾ was used to measure dietary restraint, disinhibition and hunger. This fifty-four-item questionnaire included thirty-six true/false questions and eighteen Likert-scale type questions. The validity of this questionnaire has been supported for both adolescents and adults^(18,19). The Three-Factor Eating Questionnaire was administered during the first session to obtain baseline scores.

Data analysis

All statistical analyses were performed using the Statistical Product and Service Solution software, version 11.5 (SPSS Inc., Chicago, IL, USA). For anthropometric measures as well as for activity-related energy expenditure and energy intake, the effect of time and time by sex interaction were examined using a 3 (time: September, December and March) \times 2 (sex: female and male) repeated measures ANOVA. Participants were included in these analyses if they completed all three measurements. Pearson correlations were performed between baseline variables and changes in anthropometric variables from September to December and then again for September to the end of March. To identify the best predictors of change, stepwise regression analyses included significant correlates of changes in dependent variables. Effects were considered significant at $P < 0.05$ and data are presented as means and standard deviations.

Results

Thirty of the thirty-three freshmen recruited in September returned in December and twenty-nine in March. The descriptive statistics of subjects who completed the study are presented in Table 1. A significant sex by time interaction was observed for all anthropometric measures (Table 1). Over the first semester a significant increase in body weight (1.4 kg, $P = 0.05$), WC (2.9 cm, $P < 0.01$), %BF (1.9 %, $P < 0.01$) and fat mass (1.8 kg, $P < 0.01$) was noted for men but not for women. Similarly, at the end of the academic year significant increases were observed for body weight (1.9 kg, $P < 0.05$), BMI (0.6 kg/m², $P < 0.05$), WC (2.7 cm, $P < 0.05$), %BF (3.1 %, $P < 0.01$) and fat mass (2.6 kg, $P < 0.01$) in men.

No significant effect of time for daily energy expenditure, daily energy intake, macronutrient consumption and alcohol were observed for both males and females ($P > 0.05$; Table 2). A significant sex by time interaction was identified only for the percentage of energy from protein consumed by the females during the first semester (1.7 %, $P < 0.05$).

Associations between changes in body weight, WC, %BF and baseline measures were examined with correlation analyses. All subjects were pooled because of the small sample size. These results are presented in Table 3. During the first semester, changes in body weight and WC were associated with both baseline alcohol intake (r 0.48, $P = 0.01$; r 0.51, $P < 0.01$, respectively) and baseline $V_{O_{2peak}}$ (r 0.36, $P = 0.05$; r 0.39, $P = 0.03$, respectively) (Table 3). Changes in WC were negatively correlated with baseline %BF (r -0.38, $P = 0.04$). A positive association was also noted between changes in %BF and baseline alcohol intake (r 0.63, $P < 0.01$). Over the course of the academic year, the changes in body weight were significantly negatively correlated with baseline %BF (r -0.53, $P < 0.01$). In addition, baseline alcohol intake also remained positively correlated to the changes in WC (r 0.45, $P = 0.02$) and %BF (r 0.58, $P < 0.01$). Changes in %BF were also positively correlated with baseline $V_{O_{2peak}}$ (r 0.48, $P < 0.01$) and negatively correlated with baseline %BF (r -0.41, $P = 0.03$). Dietary restraint showed a negative correlation with the change in WC and %BF over the first semester (r -0.46, $P = 0.01$; r -0.42, $P = 0.02$; r -0.44, $P = 0.02$,

Table 2. Female (n 16) and male (n 13) freshmen energy expenditure (EE) and energy intake (EI) (Mean values and standard deviations)

	September				December				March				Time × sex, P value	
	Female		Male		Female		Male		Female		Male			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
EE														
kJ	2493.7	761.9	3662.7	915.5	2405.8	809.6	3136.7	667.8	2405.0	681.6	3675.2	681.6	0.23	0.34
kcal	596.0	182.1	875.4	218.8	575.0	193.5	749.7	159.6	574.8	162.9	878.4	278.5	0.23	0.34
EI														
kJ	8168.4	15908	11013.1	1821.7	8150.9	1387.0	9991.0	2494.9	8203.6	1491.2	10276.3	2626.7	0.50	0.51
kcal	1952.3	380.2	2632.2	435.4	1948.1	331.5	2387.9	596.3	1960.7	356.4	2456.1	627.8	0.50	0.51
Carbohydrates (g)	264.9	51.0	336.6	66.6	266.1	46.8	301.0	76.9	269.9	67.1	311.0	76.4	0.45	0.37
Fats (g)	67.8	19.7	89.6	25.0	65.0	20.4	87.7	25.3	67.4	16.2	84.4	28.7	0.84	0.84
Proteins (g)	71.9	14.8	96.0	23.9	59.7	19.4	88.0	24.6	67.9	14.0	96.2	33.9	0.10	0.88
Alcohol (g)	3.7	8.0	18.1	19.2	4.0	6.4	9.9	11.9	6.0	7.6	12.8	18.0	0.15	0.08
Carbohydrates (%)	53.7	7.2	50.7	7.2	54.2	7.7	49.9	4.9	53.6	6.6	50.4	7.6	0.98	0.80
Fats (%)	30.4	4.3	30.1	5.6	31.4	7.2	32.7	4.3	30.6	6.7	30.8	4.9	0.21	0.73
Proteins (%)	14.6	2.3	14.4	2.3	12.9	1.9	14.6	2.6	13.7	2.3	15.4	3.01	0.11	0.03*
Alcohol (%)	1.3	2.9	4.9	5.7	1.5	2.1	2.7	3.4	2.1	2.6	3.4	4.6	0.25	0.08

* P<0.05.

respectively), as well as for the change in %BF over the full academic year ($r = -0.43$, $P=0.02$). Among our cohort, none of variables identified from the socio-demographic questionnaire were found to correlate with changes in body weight, WC and body fat.

To explore the best predictors of changes in adiposity, stepwise regression analyses were performed. Results presented in Table 4 show that, during the first semester, 44 % of the variance in body weight changes was explained by baseline carbohydrate and alcohol intake ($P<0.01$). Baseline alcohol intake alone also explained 26 % ($P=0.01$) and 40 % ($P<0.01$) of changes in WC and %BF, respectively. Over the full academic year, 27 % of the variance in body weight changes was explained by baseline %BF ($P=0.01$). Alcohol alone explained 20 % of the change in WC ($P=0.02$). Baseline alcohol consumption explained 34 % of the change in %BF ($P<0.01$).

Discussion

Similar to results from previous studies, we show a significant increase in body weight and adiposity over the freshmen year, most of which occurs during the first semester. Contrary to the three leading hypotheses of this paper, we also show (1) that higher pre-university adiposity levels were associated with lesser changes in adiposity; (2) that higher pre-university physical fitness levels (V_{O2peak}) were associated with greater changes in adiposity; and that (3) men gained body weight and adiposity whereas women did not during the freshmen year. Similar to findings from other studies, pre-university alcohol intake was a consistent predictor of changes in adiposity over the freshmen year.

One of the interesting observations of the present study is that displaying lower adiposity and higher physical activity before the onset of the freshmen year may not necessarily be protective against increases in body weight and fat over the academic year. This contrasts with Morrow *et al.* (8) who concluded that although normal-weight freshmen had gained body weight, those weighing more, having greater fat mass and being less active at baseline, gained more body weight during their first year. In the present study, freshmen with less %BF experienced greater increases in body weight, BMI, WC and %BF than freshmen with more %BF at the start of university. Baseline %BF explained 27 and 26 % of the change in body weight and BMI, respectively. If we assume that students who started university with higher levels of body fat were likely to consume more high-fat foods and to be more sedentary prior to university (20), it could be speculated that the transition to an environment that promotes the consumption of energy-dense foods (4,21) and low levels of physical activity (9,22–24) would have had less impact on energy balance and ultimately on energy stores. Additional support for this argument comes from the observation that freshmen in the present study with higher baseline V_{O2peak} also tended to be the ones in whom the greater changes in adiposity were noted. Hence, the resulting effect on energy balance would be expected to be greater for those freshmen who were more active before university (although this was not measured in the present study), and became relatively more sedentary as a result of the exposure to the university environment. The present findings should

Table 3. Correlation of absolute changes in body weight, BMI, waist circumference (WC) and percentage body fat (%BF) with baseline measures (*P* values)

	Change in body weight from September to		Change in BMI from September to		Change in WC from September to		Change in %BF from September to	
	December	March	December	March	December	March	December	March
Anthropometry								
Weight (kg)	0.18	-0.01	0.08	-0.02	0.15	0.15	0.24	0.35
BMI (kg/m ²)	0.02	-0.11	-0.08	-0.10	0.07	0.09	0.13	0.27
WC (cm)	0.15	-0.19	0.03	-0.18	0.04	-0.09	0.22	0.27
% BF (%)	-0.30	-0.53**	-0.27	-0.51**	-0.38*	-0.33	-0.34	-0.41*
EI								
kJ	0.47*	0.35	0.24	0.34	0.25	0.26	0.36	0.50*
Carbohydrates (g)	0.51*	0.33	0.36	0.32	0.22	0.19	0.28	0.38
Fats (g)	0.20	0.07	-0.03	0.08	0.08	0.07	0.12	0.25
Proteins (g)	0.17	0.21	-0.02	0.21	0.02	0.16	0.21	0.37
Alcohol (g)	0.48**	0.49**	0.38	0.45*	0.51**	0.45*	0.63**	0.58**
EE (kJ)	0.29	0.21	0.20	0.19	0.42*	0.18	0.26	0.19
V _{O2peak} (ml/kg per min)	0.36*	0.51**	0.21	0.48**	0.39*	0.36	0.35	0.48**
TFEQ score								
Restraint	-0.31	-0.29	-0.12	-0.29	-0.46*	-0.13	-0.42*	-0.43*

TFEQ, Three-Factor Eating Questionnaire; V_{O2peak}, peak oxygen uptake.
P*<0.05, *P*<0.01.

nonetheless be weighed against study design limitations, such as sample size and the variability of methods such as accelerometry and energy intake.

The present results show that men experienced more significant changes for all anthropometric measures than did women. It has been reported that students who are aware of the ‘Freshmen 15’ are concerned about gaining body weight, a concern more often expressed by female freshmen⁽⁶⁾. Women in the present study may thus have modified their physical activity and dietary practices throughout the year as a preventative measure against body weight gain. The observation that dietary restraint was negatively related to changes in body weight and composition in the present study and that women displayed higher dietary restraint scores than male subjects may also explain differences in body weight and adiposity over the academic year. It has been previously demonstrated that restrained eaters typically consume less energy than their less restrained counterparts^(25,26). In support of this, the present results also showed that freshmen with higher initial restraint (including both females and males) consumed significantly fewer kJ of energy and less alcohol per day at baseline. Considering the possible involvement of dietary restraint in mediating sex-related difference in freshmen

weight gain, future studies should consider assessing this variable at all time-points.

To date only one study on the ‘Freshmen 15’ examined changes in WC, reporting an increase from 69.4 to 70.3 cm over a 7-month period⁽⁸⁾. The increase in WC in the present study was more pronounced, with males showing a significant increase of 2.9 cm during the first semester and a total of 2.7 cm during the first year. Despite the fact that WC for both the females and males was below the National Institute of Health cut-off points of 88 and 102 cm, respectively⁽²⁷⁾, a linear relationship between WC and all-cause mortality was recently observed for males⁽²⁸⁾. In fact, the analysis of studies of abdominal obesity and cardiovascular outcomes revealed that a 1 cm increase in WC was associated with a 2% increased risk for CVD⁽²⁹⁾. Whether or not this increase does indeed represent cause for concern is beyond the scope of the present study.

As reported by the American College Health Association, 84.4% of university students consume alcohol⁽²²⁾. Alcohol was positively correlated with all changes in anthropometric markers observed in this cohort. The consumption of alcohol seems to increase energy intake and promote little or no compensation for its energetic content, while inhibiting the

Table 4. Stepwise regression analysis examining predictors of changes in body weight, BMI, waist circumference (WC) and percentage body fat (%BF) among freshmen (*n* 29)

Dependent variable	Step no.	Predicting variable	r ²	<i>P</i> value
September to December Change in body weight	1	Carbohydrates (g)	0.26	0.01
	2	Alcohol (g)	0.44	0.01
Change in WC	1	Alcohol (g)	0.26	0.01
	1	Alcohol (g)	0.40	0.01
September to March Change in body weight	1	%BF	0.27	0.01
	1	%BF	0.26	0.01
Change in BMI	1	%BF	0.26	0.01
	1	Alcohol (g)	0.20	0.02
Change in WC	1	Alcohol (g)	0.20	0.02
	1	Alcohol (g)	0.34	0.01

oxidation of other substrates, particularly fat⁽³⁰⁾. Further, it would also seem that alcohol favours the storage of fat in the abdominal region⁽³¹⁾. Using 3 d diet records among 135 freshmen, Horwath⁽³²⁾ reported that male freshmen obtained 3.7% of their daily energy from alcohol while this was 2.6% for their female counterparts. With the use of 7 d dietary records we found an equal percentage of energy obtained from alcohol for the males (3.7%) and less for the females (1.5%). Results from the present study reinforce the notion that the intake of alcohol may be an important contributor to increased energy intake and energy storage among freshmen students.

Conclusion

Previous observations, as well as results from the present study, show that freshmen body weight gain is less than the alleged 6.8 kg (15 pounds). Furthermore, the present study highlights the possibility that displaying lower adiposity and higher physical fitness at the onset of the university year may not be protective of increases in total and central adiposity over the course of the freshmen year. Further research involving both lean and overweight freshmen, as well as physically fit and unfit freshmen, will however be needed to confirm the findings of the present study.

Acknowledgements

É. D. is a recipient of a CIHR/Merck-Frosst New Investigator Award, a Canadian Foundation for Innovation New Opportunities Award and an Early Research Award (Ontario). G. M., K. D. and É. D. have no conflicts of interest. G. M. and É. D. were involved in the conception of the study. G. M. and K. D. conducted the experiment. G. M. and É. D. analysed and interpreted the data. G. M. wrote the paper. É. D. and K. D. revised the manuscript.

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