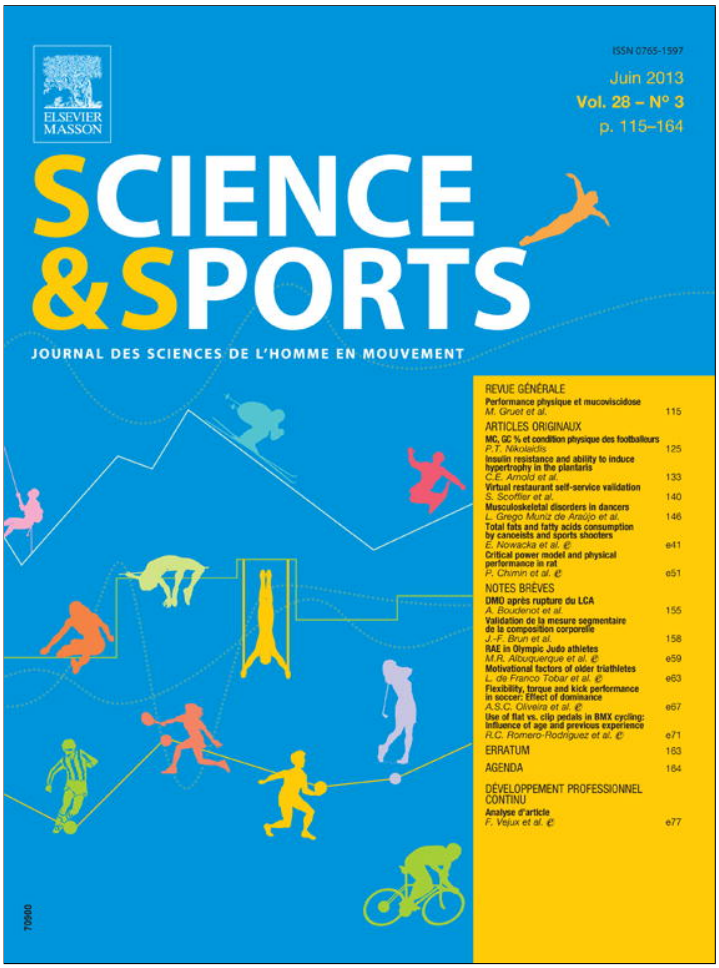

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ORIGINAL ARTICLE

Development and preliminary validation of a new instrument to assess eating behaviors: The virtual self-service restaurant (VSSR)

Développement et validation préliminaire d'un nouvel instrument d'évaluation des comportements alimentaires : le restaurant virtuel

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KEYWORDS
Eating attitudes;
Energy expenditure and intake;
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Sport;
Health prevention programs

Summary
Objectives. — The aim of this study was to develop a computerized instrument to assess eating attitudes and behaviors, the ''virtual self-service restaurant'' (VSSR), and to test for preliminary evidence of its validity. Improved measures of self-regulation in this area should facilitate the management of individuals with eating disorders, particularly athletes, and the implementation of tailored prevention and intervention programs.
Results. — This interface assesses the individual's basal metabolism, energy expenditure related to physical activity, global energy expenditure, global energy intake (i.e., difference between energy expenditure and intake), and distribution of food intake over the day. The validity of the VSSR was tested in four populations, and the results indicated satisfactory internal and external validity.
Conclusion. — This instrument, which shows preliminary evidence of validity and reliability, can be used to promote educational nutrition programs for sedentary and athletic populations.

MOTS CLÉS
Attitudes alimentaires ;

Résumé
Objectifs. — Le but de cette étude était de développer et valider de manière préliminaire un instrument informatisé pour évaluer les attitudes et les comportements alimentaires, le *virtual self-service restaurant* (VSSR). L'amélioration des mesures de l'autorégulation des

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Dépense et apport énergétiques ;
Interface virtuelle ;
Sport ;
Programmes de prévention-santé

comportements alimentaires devrait permettre de mieux accompagner les individus en général, et les athlètes en particulier, en mettant en œuvre des programmes d'intervention et de prévention adaptés.
Résultats. — Cette interface permet d'évaluer le métabolisme basal de l'individu, la dépense énergétique liée à l'activité physique, la dépense énergétique globale, l'apport énergétique global (i.e., différence entre les dépenses et les apports énergétiques), et la répartition de l'apport alimentaire au cours de la journée. La validité du self virtuel a été examinée auprès de quatre populations. Les validités interne et externe du VSSR se sont révélées satisfaisantes.
Conclusion. — Cet instrument qui a démontré des premiers indicateurs de validité et de fiabilité, pourra être utilisé pour promouvoir des programmes d'éducation nutritionnelle auprès de populations sédentaires ou sportives.

1. Introduction

The prevalence of eating disorders has become quite high among athletes in certain sports (e.g., aesthetic sports, weight-class sports, endurance sports). These sports often require frequent weight checks and complex training regimes. For instance, athletes in aesthetic sports have to conform to an ideal body weight in order to achieve an esthetically pleasing appearance and performance excellence [1]. Although many athletes initially experience an improvement in sports performance with weight loss, this improvement is generally short-lived if it was due to a drastic reduction in food intake. A major decrease in food consumption depletes energy and can be indicative of an eating disorder. Athletes in high-risk sports and others suspected of having an eating disorder should be quickly assessed and treated if necessary. More generally, it is likely that helping athletes and individuals to develop appropriate nutritional strategies to attain a desirable body profile, weight, strength, and endurance will go far in reducing the future risk of eating disorders [2].

The regulation of eating attitudes is part of the general regulation of energy homeostasis, which maintains a constant fat level. Nevertheless, decisions about what and when to eat are highly individual and vary with the individual's changing situation. In addition to the actual presence of food and the sensation of hunger, many other internal and external cues can activate the desire to eat immediately or direct the person to the choice of certain foods [3]. Indeed, the literature in social psychology and sport psychology indicates that disordered eating attitudes are developed from a complex interaction of personal (e.g., anxiety, perfectionism, self-esteem) and contextual (e.g., media influence, peer social acceptance) factors [4,5].

Several instruments for assessing eating attitudes are commonly used in psychology research. Garner, Olmsted, Bohr and Garfinkel's scale [6], validated in French by Leichner, Steiger, Puentes-Neuman, Perreault and Gottheil [7], is a well-known measure of disturbed eating attitudes and behaviors with 26 items on three subscales: (a) eating restriction, (b) bulimia and food obsession, and (c) control of eating. Garner, Olmsted and Polivy's [8] Eating Disorder Inventory (EDI) presents an inventory of the traits associated with eating disorders and thus measures the drive for thinness, bulimia, body dissatisfaction, ineffectiveness, perfectionism, interpersonal distrust, interoceptive awareness, maturity fears, and psychopathologic symptoms. In a recent review of the psychological assessment of eating disorders, Drew and Paulosky [9] noted that Van Strien, Frijters, Bergers and Defares' [10] Dutch Eating Behavior Questionnaire and Smith and Thelen's [11] Bulimia Test Revised were frequently used self-reported measures. Drew and Paulosky [9] also mentioned the use of semi-structured interviews such as Fairburn and Cooper's [12] Eating Disorder Examination, which assesses the symptoms of anorexia nervosa and bulimia nervosa, as well as the symptoms related to psychopathology. Drew and Paulosky [9] also presented behavioral measures of eating disorders such as Wilson and Vitousek's [13] Self-monitoring instrument and Williamson's [14] Test Meals, while acknowledging that these two methods are not used much because of the difficulty in implementing them.

Other instruments have been developed to measure the self-regulation of eating attitudes in daily life (e.g., Pinto, Guarda et al.'s [15] Eating Disorder Recovery Self-Efficacy Questionnaire [EDRSQ]) and in sports (Scoffier, Paquet, Corrion, & d'Arripe-Longueville's [16] Self-Regulatory Eating Attitudes Scale in Sport). The instrument of Scoffier et al. [16] is composed of 16 items, which are loaded onto five factors pertaining to the self-regulation of eating behavior in the following contexts:

- food temptation;
- negative situations;
- social interaction;
- lack of compensatory strategies;
- and lack of anticipation of consequences on performance.

Tools have also been developed for dietary assessment [17]. Five categories can be identified:

- food records;
- 24-hour dietary recalls;
- food frequency questionnaires;
- brief instruments;
- and diet history.

These dietary assessment methods present several advantages such as: quantification of food intake, no requirement to recall foods eaten, appropriateness for most

populations, information on total diet, and low investigator cost. They also present several disadvantages such as: high investigator cost, many days needed to capture an individual's usual intake, difficulty of the cognitive task for respondents, and frequent misreporting of intakes.

According to Title IV of the Code of Conduct of the French Society of Psychology for researchers in the behavioral sciences, direct observation of the attitudes and behaviors related to eating disorders is unethical. The tools currently in use are thus based on the self-reported level of eating disorder (i.e., the levels of various components of eating disorders) [6,8], the self-reported ability to control eating behaviors or attitudes [15,16], or the food record or diet history, which carries high investigator cost or the risk of often misreported intakes. Such instruments, which depend on personal assessment, may generate social desirability bias when they are used to assess sensitive or taboo matters like one's relationship to food.Given the specific issues and social influences pertaining to eating behaviors, the existing tools thus have obvious limitations. The development and validation of a specific tool, such as a virtual interface allowing subjects to individually project their eating habits, seemed necessary to better assess, explain and prevent eating disorders. Indeed, such a tool could help individuals and athletes to more easily assess their usual food intakes and energetic expenditure via an ergonomic interface. The aim of this study was therefore to develop and validate a computerized instrument to assess actual food intake (i.e., food choice, amount eaten, meal sizes and meal frequency): the ''virtual self-service restaurant'' (VSSR), to enable individuals to compose virtual meals by selecting food through a graphical user interface. Our intention was to provide better assistance to researchers and therapists in measuring the food intake of, respectively, their participants and patients. The virtual projection of an eating attitude is personal and without social or environmental pressure because the participant can complete the activity at the most convenient time on the Internet. The self-service restaurant was developed and validated in successive stages:

- elaboration of the interface;
- assessment of its clarity;
- and assessment of its internal and external validity.

1.1. Stage 1: elaboration of the virtual self-service restaurant (VSSR)

The VSSR is a virtual interface for choosing the composition of five meals a day from a wide range of food offerings (Appendix 1). Geier and Rozin [18] showed that the evaluation of the caloric content of a meal was biased by the unstandardized units (i.e., the quantity of a portion) and the tendency to choose a single variable for assessing the quantity (i.e., either weight or size). Research in the field of nutrition has shown that, generally, when eating behavior is projected virtually individuals ignore the thickness of a piece of food and concentrate on its size [19], and judgments of size tend to decrease as the absolute size increases [20]. In addition, individuals develop rules for evaluating the number of calories based on what seems to be a standard size for the food in question [21], and foods perceived as healthier are assumed to have lower caloric density [20]. Thus, in order to curb these biases in the virtual screening of food intake and to obtain quantity assessments that are as accurate as possible, the VSSR does not mention the number of calories but refers only to the type of container (e.g., glass, bowl, soup spoon). The perception of the quantity of each food chosen by the participants is based on personal eating habits using measured quantities from a container. A picture is used as a guide for each food. Two sport dietitians who viewed this method as an appropriate means for assessing athletes' food habits agreed to evaluate the interface.

This interface assesses: (a) basal metabolism using Black, Coward, Cole and Prentice's [22] equation[1], (b) the energy expended for physical activity, and (c) the overall energy expenditure. Regarding the energy expended for physical activity, we used the compendium of physical activity of Ainsworth and colleagues [23], which comprises 80 sports at several intensities (i.e., the participant specifies the type of activity and provides the number of hours and minutes performing the activity; the software then estimates the energetic requirement averaged base on a table of physical activity of energetic expenditures in relation to anthropometric measurements, as based on the dietary calculations). The overall energy intake is assessed from the food choices made for a given day, and all these data are then used to calculate the difference between energy expenditure and energy intake and the distribution of food intake throughout the day. The calculation of the difference between energy intake and energy expenditure can provide the self-regulation of eating attitudes. When energy intake and expenditure are balanced, good self-regulation of eating attitudes can be assumed. With increasingly greater imbalance between energy intake and expenditure, increasingly less optimal self-regulation of eating attitudes should be suspected.

1.2. Stage 2: study of the clarity of the virtual self-service restaurant

The clarity of the interface of the VSSR was tested on 15 students regularly practicing club sports (minimum six hours per week) (M_{age} = 21.00; SD_{age} = 0.28). Five questions were chosen by an expert committee composed of three researchers working in the areas of eating disorders and social psychology:

- Is the interface of the VSSR clear?
- Are the food choices easy to make?
- Are the food images representative?
- Is the way the food quantities are presented appropriate for composing meals?
- Is the number of individual foods offered sufficient?

[1] [i.e., Male = [1.083 × Weight (kg) 0.48 × Height (m) 0.50 × Age (yr) − 0.13] × (1000/4.1855); Female = [0.963 × Weight (kg) 0.48 × Height (m) 0.50 × Age (yr) − 0.13] × (1000/4.1855)]; kg: kilograms, m: meters.

Each item was assessed with a Likert-type scale on four points from 1 (Not at all) to 4 (Totally). All participants attributed 3 or 4 points to each item, which strongly indicated the overall clarity of the tool (M_{age} = 3.80; SD = 0.41).

Based on interviews with the participants in the clarity test, some adjustments in terms of describing quantities were made to improve the ease of use. Thus, sauces to add flavor to food were added, and their caloric value, although masked for participants, was calculated.

1.3. Stage 3: study of the internal and external validity of the virtual self-service restaurant

The aim of this third stage was to assess the internal and external validity of the VSSR. The internal validity was tested in four samples:

- adolescents;
- adolescent athletes in high-risk sports;
- adolescent athletes in other sports;
- and adults.

Therefore, the external validity of the VSSR was asserted among all internal validity assessment.

2. Method

2.1. Participants

Four groups of participants were asked to test the applicability of this instrument to their respective populations: adolescents, adolescent athletes in sports in which weight is an important concern, adolescents in other sports, and adults. The sample of adolescents (n = 21; M_{age} = 13.65; SD_{age} = 0.65) was composed of 13 females and nine males. This group was characterized by an average weight of 131.63 pounds (SD = 34.63) and an average height of 5.57 feet (SD = 0.07). The sample of adolescent athletes in sports in which weight was a major preoccupation (i.e., aesthetic sports, weight-class sports, endurance sports) (n = 22; M_{age} = 25.31; SD_{age} = 4.70) was also composed of 13 females and nine males. This group was characterized by an average weight of 131.638 pounds (SD = 34.63) and an average height of 5.57 feet (SD = 0.07). The sample of adolescent athletes in other sports (i.e., team sports, dual sports such as tennis) (n = 20; M_{age} = 26.42; SD_{age} = 5.67) was composed of 12 females and eight males. This group was characterized by an average weight of 136.90 pounds (SD = 23.54) and an average height of 5.54 feet (SD = 0.09). The sample of adults (n = 23; M_{age} = 33.65; SD_{age} = 10.49) was composed of 13 females and 10 males. This group was characterized by an average weight of 146.60 pounds (SD = 29.23) and an average height of 5.61 feet (SD = 0.07).

2.2. Procedure

The participants carried out two measures in random order, with a three-day interval: (a) the report of food intake over the course of a day and (b) the VSSR choices. Half of each group thus completed the VSSR first and the other half completed the food intake report first. For the measure of the actual food intake, each participant recorded all food intakes in a notebook on a specific day. Food intake was converted into energy intake using Diondine© software [24]. For the measure of the virtual food intake, each subject visited the VSSR and made food choices over a full day among the foods offered. Thus, each participant had to choose each component of a meal in terms of quality and quantity (i.e., food types and quantities of energy intake) from among the foods offered as a buffet for each meal (i.e., breakfast, snack, lunch, snack, dinner).

2.3. Analysis

We analyzed the recorded energetic intakes and the VSSR choices for each group using descriptive statistics and the Student t test for paired samples. Moreover, a significant linear regression was used to demonstrate that the two variables were related. The level of significance was retained at $P \leq 0.05$.

3. Results

3.1. Internal validity in the adolescent sample

The participants documented an average intake of 1925.60 Cal (SD = 590.76) in the VSSR and 1783.45 Cal (SD = 515.84) in the notebook. Thus, we observed an average difference of −109.40 Cal (SD = 317.26) between the two measures (i.e., notebook energetic intake − VSSR energetic intake). However, the Student t test for paired samples was not significant (t = −0.313; P = 0.758). The linear regression was significant (β = 0.93; P < 0.01) and demonstrated that the two variables were related.

3.2. Internal validity in the sample of adolescent athletes in high-risk sports (aesthetic sports, weight-class sports, endurance sports)

The participants documented an average intake of 1906.90 Cal (SD = 600.66) in the VSSR and 1790.40 Cal (SD = 505.87) in the notebook. Thus, we observed an average difference of −116.50 Cal (SD = 329.37) between the two measures (i.e., notebook energetic intake−VSSR energetic intake). However, the Student t test for paired samples was not significant (t = −1.66; P = 0.11). The linear regression was significant (β = 0.83; P < 0.01) and demonstrated that the two variables were related.

3.3. Internal validity in the sample of adolescent athletes in other sports (team sports)

The participants documented an average intake of 1718.45 Cal (SD = 479.10) at the VSSR and 1692.45 Cal (SD = 426.73) in the notebook. Thus, we observed an average difference of −26.00 Cal (SD = 196.27) between the two measures (i.e., notebook energetic intake − VSSR energetic intake). However, the Student t test for paired samples was not significant (t = −0.59; P = 0.56). The linear regression was significant (β = .91; P < 0.01) and demonstrated that the two variables were related.

3.4. Internal validity in the sample of adults

The participants documented an average intake of 1875.34 Cal ($SD = 451.86$) in the VSSR and 1891.30 Cal ($SD = 351.80$) in the notebook. Thus, we observed an average difference between the two measures (i.e., notebook energetic intake − VSSR energetic intake) of −15.85 Cal ($SD = 191.69$). However, the Student t test for paired samples was not significant ($t = 0.39$; $P = 0.69$). The linear regression was significant ($\beta = 0.92$; $P < 0.01$) and demonstrated that the two variables were related.

The results pertaining to all the populations under study revealed no significant differences between the energetic intakes of the VSSR and the notebook. Therefore, both the internal and external validity of the VSSR can be asserted.

4. General discussion

The aim of this study was to develop and validate a computerized instrument to assess actual food intake, the VSSR, to enable individuals to compose virtual meals by selecting food through a graphical user interface, thereby better assisting researchers and therapists in measuring eating attitudes and behaviors. This new tool captures eating attitudes ecologically without departing from ethical guidelines. The development and validation of the virtual restaurant required three stages:

- elaborating the VSSR;
- verifying its clarity;
- and demonstrating its internal and external validity.

The preliminary results of this study indicate that the VSSR is a valid instrument for assessing the following:

- the basal metabolism of study participants, using the equation of Black et al. [22];
- the energy expended for physical activity, with reference to 80 sports at several intensities;
- and the global energy expenditure.

Based on the virtual projection of eating attitudes, we calculated the global energetic intake. Then, using this calculated index, we assessed the difference between energy expenditure and intake and the distribution of food intake over the day.

Several limitations became apparent during the course of this validation study. First, the moment in time and the situational context of an individual at that time undoubtedly contribute to his or her nutritional state and this would also affect the outcome of the virtual experiment. Moreover, a true picture of an individual's habitual food intake is generally obtained by averaging the daily intakes calculated over a prolonged period of time (weeks or months rather than days) [25]. Studies are thus needed to further test the validity of this instrument using repeated measures and independent samples; with regard to athletes, high skill-level participants should also be included. These results also need to be replicated in larger samples of participants overall, and particularly in larger samples of athletes at-risk and not at-risk for eating disorders. Future studies should also verify that the scores obtained on this self-reported instrument are significantly related to current or objective measures of food intake. This instrument could be adapted by changing the food selection according to the season of the year, and it could also be adapted to other cultures and translated into other languages to examine its cross-cultural validity.

Second, it is difficult to accurately estimate energy intake. Our inability to obtain good information on food intake could be succinctly described by Blundell [26] as ''(...) a dilemma for nutrition (...) but an enigma for psychology.'' Differential reporting of nutrients is the inevitable end result of differential reporting of foods and meals. If dietary assessments are to be improved, we must understand which foods and meals are misreported.

In another way, energy intake is not compared to energy requirement set by energy expenditure. This analysis was not taken into account in this validation study because it would not have allowed us to verify the validity of the instrument. The interpretation of this comparison should be the aim of another study in relationship with the self-regulation of eating attitudes capacities [16].

Because the VSSR assesses the balance between energetic expenditure and intake, it can be used to measure the self-regulation of eating attitudes in adolescents and adults, as well as in athletes. This interface should be useful for research purposes. For instance, such a tool could be used to follow cohorts in epidemiological investigations to identify the risk factors for eating disorders. Interventional trials with control group comparison could be conducted, with repeated measures of self-regulation of eating attitudes through the VSSR. This instrument would also be useful in the prevention of disordered eating by helping individuals to become more aware of their energy needs and the energy intake they virtually plan on a typical day. The VSSR immediately picks up an imbalance in these two values and can then be used to better regulate feeding behavior through the objectification of these variables.

In the sport context, this tool could also help athletes to focus on personal nutritional needs based on day-to-day changes in the schedule of training intensity and volume. Over time, this would develop greater awareness of fluctuating energy requirements and sharpen the athlete's ability to regulate eating behavior over the course of a sport season. An important point is that little time is needed for the VSSR, making it compatible with the busiest schedules, such as those of elite athletes. Last, the VSSR indicates the projected distribution of food intake during the day and, particularly for athletes; this can be compared with the distribution of physical activity that day. Ways to optimize the distribution of dietary intake can then be considered. For the other populations, the VSSR is a valid instrument for enhancing awareness of food intake and its distribution during the day. It thus might be easily adapted for national campaigns to improve nutritional health in different segments of the French population.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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Contributors: All authors designed the study and wrote the protocol, conducted literature searches and provided summaries of previous research studies, and conducted the statistical analysis. All authors contributed to and have approved the final manuscript.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.scispo.2012.03.003.

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