European Journal of Human Movement, 2014: **33**, 152-167

VALIDATION OF AN INSTRUMENT FOR INJURY DATA COLLECTION IN STRENGTH TRAINING

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ABSTRACT

Purpose: To provide for the basis for collecting strength training data using a rigorously validated injury report form. Methods: A group of specialist designed a questionnaire of 45 item grouped into 4 dimensions. Six stages were used to assess face, content, and criterion validity of the weight training injury report form. A 13 members panel assessed the form for face validity, and an expert panel assessed it for content and criterion validity. Panel members were consulted until consensus was reached. A yardstick developed by an expert panel using Intraclass correlation technique was used to assess the reability of the form. Test-retest reliability was assessed with the intraclass correlation coefficient (ICC).The strength training injury report form was developed, and the face, content, and criterion validity successfully assessed. A six step protocol to create a yardstick was also developed to assist in the validation process. Both inter-rater and intra rater reliability results indicated a 98% agreement. Inter-rater reliability agreement of 98% for three injuries. Results: The Cronbach's alpha of the questionnaire was 0.944 ($p<0.01$) and the ICC of the entire questionnaire was 0.894 ($p<0.01$). Conclusion: The questionnaire gathers together enough psychometric properties to be considered a valid and reliable tool for register injury data in strength training, and providing researchers with a basis for future studies in this area.

Key Words: data collection; validation; injury prevention; strength training

RESUMEN

Objetivo: Elaborar un cuestionario válido, fiable y reproducible para registrar las lesiones en el entrenamiento con cargas. Metodología: Un grupo de especialistas diseño un cuestionario de 45 ítems dividido en 4 dimensiones. Se utilizaron 6 fases para evaluar la validez de contenido, constructo y de criterio del cuestionario para el registro de las lesiones. Un panel de 13 expertos evaluó el cuestionario. Los miembros fueron consultados hasta que se llegó a un consenso. Se utilizó la técnica de correlación intraclase para evaluar la fiabilidad del cuestionario. Un test-restest fue realizado mediante el coeficiente de correlación intraclase (ICC). Resultados: El alfa de Cronbach del cuestionario fue 0,944 ($p <0,01$) y el ICC fue 0,894 ($p <0,01$). Tanto los resultados intra e inter observador indicaron un acuerdo de fiabilidad del 98%. Conclusiones: El cuestionario reúne suficientes propiedades psicométricas como para ser considerado un instrumento válido y fiable para el registro de los datos sobre lesiones en el entrenamiento de fuerza, y proporcionar a los investigadores una base para futuros estudios en esta área.

Palabras clave: registro de datos; validación; prevención de lesiones; entrenamiento de fuerza

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Submitted: 05/10/2014
Accepted: 21/11/2014

INTRODUCTION

Each year in the United States, the National Electronic Injury Surveillance System (NEISS) recorded an estimated 25.335 weight-training related injuries between 1990 to 2007 (Kerr, Collins, & Comstock, 2010). Several epidemiological studies show that there are exercises potentially dangerous due to lack of qualified instruction, a poor exercise technique, an inappropriate training load or safe equipment and the number of injuries reported has increased proportional to participation in specific strength training and competition (Kerr, et al., 2010; Myer, Quatman, Khoury, Wall, & Hewett, 2009; Quatman, Myer, Khoury, Wall, & Hewett, 2009; Stone, Fry, Ritchie, Stoessel-Ross, & Marsit, 1994). And although, the latest findings showing that this type of training is beneficial to health and the reduction in the incidence and mortality associated with cardiovascular disease, diabetes, obesity, hypertension and osteoporosis (Ades, Ballor, Ashikaga, Utton, & Nair, 1996; Ruiz et al., 2008; Warburton, Glendhill, & Quinney, 2001), physical activity and strength training program are associated with health risks, mainly musculoskeletal injuries (Hootman, Dick, & Agel, 2007; Kerr, et al., 2010; Lubetzky-Vilnai, Carmeli, & Katz-Leurer, 2009) and has become a concern to different emergencies departments and government security agencies (Dick, Agel, & Marshall, 2007; European Home and Leisure Accident Surveillance System, 2006; NEISS, 2009).

On the other hand, various studies have found that variations in injury definitions, methodologies, and analyses amongst studies can lead to differences in results and conclusion obtained and this variety makes impossible comparing studies even though these belong to the same field or group (Best & Shrier, 2007; Brooks & Fuller, 2006; Clarsen, Myklebust, & Bahr, 2013). For these reason, everyone involved in the care of athletes or recreational sportsmen and their wellbeing recognizes the importance of injury prevention, treatment and standardised assessment of sport injuries to provides not only important epidemiological information, but also show directions for injury prevention (Finch & Cassell, 2006; Fuller, 2007; Meeuwisse, Tyreman, Hagel, & Emery, 2007). The development of standardised data collection instrument to assess incidence rates is critical to methodological injury research (Turocy, 2002). And although many experts recommend the use of valid and reliable measurement instruments in resistance training (Best & Shrier, 2007; Keogh, Hume, & Pearson, 2006; Turocy, 2002) very few studies have discussed the validation of these instruments.

Most studies used only hospital databases or injuries caused in strongman, powerlifting or weightlifting using different procedures to injury recorded. In addition, the injury definition, severity and incidence rate it not was the same and recorded in all studies (Keogh, et al., 2006; Kerr, et al., 2010; Mazur,

Yetman, & Risser, 1993). For this reason, the aim of this study is to provide the valid injury questionnaire report in specific strength sport.

METHOD

To develop of research study was established the methodology of Survey Research in Athletic Training (Turocy, 2002). A six stage process was used to develop and validate the strength training injury report form. It involves a sequential process that ensures that the information gathered is useful and useable. Table 1 provides an overview of the plan of action for a survey study. Each area of this plan is discussed in more detail in subsequent sections.

TABLE 1
Survey-Research Plan of Action (Turocy, 2002).

Stage one	Develop a research question and subtopics; specify a hypothesis if one exists.
Stage two	Investigate existing literature on the topic and subtopics; be sure to examine works done in other health professions.
Stage three	Clarify and refocus the research question(s) if appropriate.
Stage four	Establish the validity of the instrument; if the instrument is appropriate for other disciplines but not athletic training, rework instrument and validate using method described below. a. Develop a Table of Specifications. b. Develop an instrument based upon the table of specifications. c. Validate the instrument
Stage five	Determine the sample.
Stage six	Acquire and analyze the data.

The questionnaire was designed by a group of specialists. Participating was a multidisciplinary team with 10 members, made up of teaching staff from the Faculty of Sport Science in Madrid. They are specializing in strength training and sport injury, as well as graduates in physical activity and sport science with professional connections to the personal training in Spain. The specialists drew up a list of question and subtopics to be evaluated and the dimensions that should ultimately be included in the questionnaire to create a Table of Specifications (ToS) and compared with literature review. The ToS delineates the main topics of the survey: personal details, injury information, training data and others. The ToS was used as a guide to develop appropriate questions and to determine criterion-related validity and the plan for item analysis. As questions or items are developed, they should be assigned to a topic area in the ToS. Items should fit into one of the categories of the ToS; an item can be reworded to fit more appropriately into a category, or it may be placed aside for use in a future study. The instruments available for evaluating some of the

factors relevant to the injury were reviewed and it was decided that closed answer items should be composed.

TABLE 2
Categories included in the preliminary questionnaire.

Categories	Variables	Authors
Physical Activity or Specific strength training	Specific strength sport: Weightlifting, powerlifting, strongman, Crossfit, Recreational strength training, Atheltic Training, Bodybuilding	(Caine, Caine, & Lindner, 1996; Mazur, et al., 1993; Risser, 1990)
Objetives	Purpose and type of training.	(Caine, et al., 1996; Keogh, et al., 2006)
Intensity	Time of year, experience, type of work performed, percentage of 1RM intensity relative to the speed of execution, number of sets and exercises and rest.	(Roald Bahr & Engebretsen, 2011; R. Bahr & Krosshaug, 2005; Caine, et al., 1996; Mann, Lamberts, & Lambert, 2013; Raske & Norlin, 2002)
Duration and Frequency	*Duration* is the length of time (usually minutes) an activity is continued. *Frequency* is the number of times an activity is performed within a specified time period, usually expressed as bouts, episodes, or sessions per week.	(R. Bahr, 2009; Powell, Paluch, & Blair, 2011)
Accumulation	*Accumulation* is the assembling of short episodes of physical activity during a limited period of time (usually one day) to achieve a fuller amount	(Reeves, Laskowski, & Smith, 1998; Reynolds et al., 2001)
Environmental Factors	Ambient temperature, humidity and ventilation, type of equipment, belt usage, type of coach, ergogenic aids, etc..	(Bahrke & Yesalis, 1994; Caine, et al., 1996; Haupt, 2001; Renfro, 2006)
Individual factors	Genetics, age, sleep, nutrition, predisposition to injury, previous injuries training goals, etc.	(R. Bahr, 2009; R. Bahr & Krosshaug, 2005; Caine, et al., 1996; Calhoon & Fry, 1999; Clarsen, et al., 2013)

The questions included in the Preliminary_1 questionnaire were selected based on consensus between the researchers. They were drawn up in a clear, simple and concise manner to ensure that less time and attention were required from injured sportsmen, and they were kept neutral so as not to influence their answers. Questions drawn up in a negative manner were avoided, as were questions requiring the use of memory or effort since the questionnaire was aimed at people who practiced occasionally some training in sport centers. As regards the order of the questions, the simplest were placed at

the beginning, the weightiest in the middle and the least relevant were left until the end. The questionnaire was constructed in a logical order, by subject group. The effect of any questions contaminating or creating bias in others during completion of the questionnaire was avoided. In accordance with the indications of Aday (Aday & Cornelius, 2011), we believe that a minimum of 6 items should be considered in order to evaluate a dimension.

To ensure the accuracy of the data collected and the conclusions derived from the results, we performed tests of validity and reliability through different ways (table 3). A total of thirteen experts participated in the process of validating the preliminary questionnaire. The preliminary questionnaire was sent to the experts along with a document entitled "Questionnaire evaluation", allowing them to assess the following aspects of each item: relevance, content and wording. Each of the items was evaluated using a scale numbered from 1 to 6, with 1 corresponding to "completely unsuitable" and 6 to "very suitable". A section was left for adding remarks for each item. The survey is revised and returned to the experts to reconsider their responses based on all of their original answers. The survey is revised again and returned to the experts for additional feedback. And finally, by reaching an expert consensus, we made the final questionnaire Preliminar_2 (Best & Shrier, 2007; Scott, 2001; Thomas, Nelson, & Silverman, 2005).

TABLE 3
Types of validity.

Validity	Overview
Face	Evaluation by experts and sample participants to determine whether they believe that the instrument measures what it is intended to measure.
Content	Experts ensure that the content of the questionnaire accurately assesses all essential aspects of the topic.
Construct	Experts agree with the hypothetical constructs (causes) that the investigator suggests underlie the research question
Criterion-related	Evaluation to determine that all items used in the survey are related to specific criteria to be analyzed.

Finally, test–retest reliability was assessed by administrating two identical interviews with the same interviewer. A 2-week time interval was considered enough time for patients not to remember their previous answers and the κ index was used to evaluate the interobserver variability.

The study details were explained to the injured athletes, and if they agreed to participate, they gave informed consent. The consent guaranteed that the information collected would be kept private under Organic Law 15/1999 of 13th December on personal data protection.

Developing the instrument

A sport injury was defined according to the recommendation made by Council Of Europe as "any injury occurring as a result of sport activity and causing one or more of the following: the subject had to stop sports activity and/or could not fully participate in the next planned sports activity and/or bit go to work the next day and /or needed medical attention" (Fuller et al., 2006; Junge et al., 2008; Keogh, et al., 2006; Luthje et al., 1996; Timpka et al., 2014; Winwood, Hume, Cronin, & Keogh, 2014).

Different tests were conducted to assist in the assessment of reliability using the procedures of Streiner and Norman (Streiner, Norman, & Fulton, 1991). We used the questionnaire in a clinical trial which used free weight training and cross training (Zapico et al., 2012). Based on our power calculations (Donner & Eliasziw, 1992) it was estimated that ' 'test–retest' ' would tested on a sample of 100 subjects (60% of the study population) to detect a κ of ≥ 0.4 at 0.80 power. The retest response was made with 2-week interval.

The following exclusion criteria were established using the results obtained from the evaluation of the preliminary questionnaire and the statistical analyses.

- First criterion: Exclusion requested by at least two of the experts.
- Second criterion: Obtaining a score for an independently evaluated item that falls below a confidence interval of 95% with respect to the average for the entire test, as well as a coefficient of variation greater than 25% for the relevance and content parameters.

Additionally, all items meeting any of the following criteria were reviewed:

- First review criterion: Requested by at least one of the experts.
- Second review criterion: Obtaining a lower-than-average score for the relevance and content parameters, as well as a coefficient of variation of 20% or more in the wording criteria evaluated by the experts.

The final questionnaire was obtained by applying these criteria to the preliminary questionnaire.

Statistical analysis

Version 15.0 for Windows of the program SPSS (*Statistical Package for the Social Sciences*) was used. The statistical significance level was set at alpha ≤ 0.05. The following statistical analyses were used for the validation process: Central tendency and dispersion statistics were used by the evaluators to assess the questionnaire. The Mann-Whitney U test was used to compare the scores given to the evaluated sections and the different dimensions of the questionnaire by the two groups of experts. To observe the aggregation or relationship of the answers in the three sections (relevance, content and

wording), Spearman's Rho was used for bivariate analysis and the intraclass correlation was used to observe the relationship between the three sections as a whole.

Test–retest reliability was quantified using κ with 95% (Fuller, et al., 2006) and the intraclass correlation coefficient (ICC). For the statistical analysis of the reliability of the final questionnaire, Cronbach's alpha coefficient was used to evaluate internal consistency, i.e. the degree of convergence of each item with respect to its corresponding dimension.

RESULTS

Validity

The design and content of the strength training injury report form for competition and training was devised from recommendations for future research elicited from the literature reviewed and a review of existing data collection instruments.

Table 4 shows the Mean ± SD of the item scores given to each of the categories by the experts.

TABLE 4
Mean score and standard deviation after evaluation by each expert].

	Relevant		**Content**		**Wording**		**Total**	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
Statistic_1	5.03	±1.44	4.830	±0.955	5.096	±1.034	4.988	±0.260
Statistic_2	4.54	±1.69	4.925	±0.781	4.811	±1.110	4.761	±0.462
Statistic_3	5.92	±0.33	5.358	±1.210	5.698	±0.992	5.660	±0.458
Statistic_4	5.98	±0.13	5.717	±0.717	5.189	±1.075	5.629	±0.473
Expert_1	5.34	±0.96	5.245	±0.939	4.453	±1.856	5.013	±0.524
Expert_2	5.62	±1.18	5.321	±1.268	5.623	±0.945	5.522	±0.167
Expert_3	5.50	±1.29	5.509	±1.012	5.577	±1.073	5.532	±0.149
Expert_4	5.47	±0.93	5.075	±1.238	5.288	±1.016	5.279	±0.158
Expert_5	4.60	±1.59	4.585	±1.646	5.189	±1.630	4.792	±0.025
Expert_6	5.54	±1.24	5.132	±1.301	5.811	±0.652	5.497	±0.361
Expert_7	5.67	±0.47	5.962	±0.275	5.962	±0.275	5.868	±0.113
Expert_8	5.67	±0.95	5.283	±1.246	5.415	±1.216	5.459	±0.159
Expert_9	5.94	±0.41	5.906	±0.354	5.943	±0.305	5.931	±0.054
MEAN	**5.45**	±0.97	**5.296**	±0.996	**5.389**	±1.014	**5.379**	±0.259
STD_DEV	0.46	±0.50	0.406	±0.389	0.446	±0.441	0.384	±0.175

Table 5 shows the result of comparing the two groups of experts with each of the three categories by performing the Mann-Whitney U test.

TABLE 5
Results of the Mann-Whitney U analysis to compare the means obtained by each group of experts for each of the criteria to be evaluated.

	Relevant	**Content**	**Wording**
Mann-Whitney U	17	16	6
P (Sig. (1-tailed))	0.660	0.558	0.390
Statisticians (mean ± σ)	5.366	5.257	5.080
Experts (mean ± σ)	5.507	5.347	5.575

There are no significant differences between the experts and the statisticians in terms of their evaluation of the relevance, content and wording of the items on the questionnaire.

Table 6 shows the results of the correlation between the three aspects to the experts consulted.

TABLE 6
Analysis of the Pearson correlation between the criteria of relevance, content and wording of bivariate way.

	Correlation	**Significant (bilateral)**
Relevant-Content	0.419	< 0.001
Relevant-Wording	0.202	< 0.001
Wording-Content	0.424	< 0.001

The variables analyzed have significant value but with low correlations, the lowest relationship was the Relevance-Wording.

The ICC for observing the relationship between the three sections as a group showed moderate result of 0.558, with a confidence interval of 95% among all sections analyzed in common.

Application of the first and second exclusion criteria led to the elimination of twelve items from questionnaire Preliminar_2. After applying the two item review criteria we had to modify various spelling, wording, expression and content aspects. Furthermore, in line with the recommendations made by experts in the "remarks" section, we added 2 new items to the questionnaire. In the end, the final questionnaire was drawn up with the following dimensions and their corresponding categories.

TABLE 7
Shows the dimensions assessed by the questionnaire and their respective categories.

Individual factors	Gender, age, weight, height, type of work, type of training, goal, previous experience, training frequency
Injury Detail	Injury date, type of injury, severity of incidents, anatomical site, musculoskeletal diagnoses, body area, subsequent injuries, recurrent conditions,
Training Detail	Type of training, duration, frequency, intensity, type of exercise, muscular group, rest between exercises, volume.
Other	Other physical activity, genetic, nutrition, sleep, hydratation, pathologies.

After performing the corresponding analyses for validating the questionnaire, we conducted the statistical analyses necessary to determine its reliability. Table 5 uses Cronbach's alpha to show the internal consistency of each of the 4 dimensions and of the questionnaire as a whole.

Reliability

One hundred and eleven injuries were recorded with the questionnaire, and 90 also responded to the retest questionnaire 2 week later. The weighted kappa was excellent (Kappa > 0.90) according to the interpretation scale of Landis and Koch (Landis & Koch, 1977) and the proportion of agreement ranged from 0.91 to 1. There were no major differences in test–retest reliability between the use of the weighted kappa, the Spearman's rho and ICC. In our study, all items in questionnaire showed almost perfect agreement, defined as $\kappa>0.80$ (Sim & Wright, 2005). The period between test and retest showed no significant changes in responses.

DISCUSSION

A review of published literature failed to find a valid measurement instrument for collection of injury data in strength sports and the results of this study showed that the designed specific strength injury questionnaire was highly valid and reliable.

The most important criteria that relate directly to questionnaire development are: definition of injury, validity, and reliability. A group of sport injury specialists reported that standardized definitions of injuries were essential to allow comparison of results between studies in the same sport and also studies of subpopulations within and between sports (Best & Shrier, 2007; Clarsen, et al., 2013; Timpka, et al., 2014). In fact, recent works published about the incidence and severity injuries in specific strength sports (Keogh, et al., 2006; Weisenthal, Beck, Maloney, DeHaven, & Giordano, 2014; Winwood, et al., 2014) have incorporated the definition of injury according to this consensus

(Fuller, et al., 2006; Timpka, et al., 2014). However, few studies showed the questionnaires, the injury classification system used or have not shown the reliability, although this procedure is considered essential to injury data collection (Atkinson & Nevill, 1998; Macarthur, Dougherty, & Pless, 1997; Turocy, 2002; Weir, 2005).

The popularity of weight training has grown over the past decade and the factors that led to the increase included promotion of active lifestyles among older adults and programs that specifically promote strength training for health throughout life to sustain functional independence for activities of daily living, improve physical performance, movement control, walking speed, cognitive abilities, and self-esteem (Faigenbaum & Myer, 2010; Ruiz, et al., 2008; Westcott, 2012) and also, over the past twelve years, the CrossFit has grown to include almost 3500 affiliated gyms worldwide (Hak, Hodzovic, & Hickey, 2013). However, specific strength sports also showed an association with health risks, mainly musculoskeletal injuries (Calhoon & Fry, 1999; Hak, et al., 2013; Haupt, 2001; Keogh, et al., 2006; Kerr, et al., 2010; Winwood, et al., 2014) and for these reason, several authors try to explain if it is possible obtain valid data from injury surveillance system, from sports trainers or Injury reporting via SMS text (C. Ekegren, B. Gabbe, & C. Finch, 2014; C. L. Ekegren, B. J. Gabbe, & C. F. Finch, 2014; Nilstad, Bahr, & Andersen, 2014). For instance, several epidemiological studies explain that if in the questionnaire the minor injuries are omitted, the true incidence of injury relating to sport may be significantly underestimated. This occurs in different articles that only used the emergencies injuries recorded (Kerr, et al., 2010; Myer, et al., 2009; Quatman, et al., 2009). This finding suggests that if we not recorded injuries during training sessions, our data may have information bias and show inconsistent conclusions (R. Bahr & Krosshaug, 2005; Brooks & Fuller, 2006; McManus, 2000; Timpka, et al., 2014) and this also means that injury incidence based on the medical staff registration is substantially lower than the incidence calculated from individual registrations (Nilstad, et al., 2014) and we could use in gyms or sports centers that lack medical staff.

Additionally, the consensus statement on the conduction of epidemiologic studies in football (Fuller, et al., 2006) recommended that injuries should be identified and classified by a member of the team medical staff and Sports injury research. Although recently Ekegren et al (C. Ekegren, et al., 2014) have shown that the profile of injuries reported by sports trainers was consistent with previous studies and there was a high level of completeness of injury records. Even so, in our study the questionnaire incorporates the Orchard sports injury classification system (OSICS) to streamline data input. If sports centers have a medical team, the OSICS is one of the world's most commonly used systems for coding injury diagnoses in sports injury surveillance systems.

Its major strengths are that it has wide usage, has codes specific to sports medicine and that it is free to use (Hammond, Lilley, & Ribbans, 2008; Orchard et al., 2010).

Once injury definitions, severity and classification was determined, the next decision was to collect injury data in situ (Zapico, et al., 2012) to observe the validity and reliability of our data collection forms. A poor reproducibility limits the ability of researchers to reach conclusions and we need to know about the accuracy with which these measurements are made. This study showed that the intraclass correlation coefficient (ICC) has a high level of test-retest reliability. As this is a questionnaire that does not require memory and takes little time to complete, it is most feasible to implement it in sport centers where it could be of great use for assess incidence, prevalence and severity and which exercises are most dangerous during different type of specific strength training or competition. Even, the development of new technologies will allows us to record injuries in a web or mobile application (C. L. Ekegren, et al., 2014; Nilstad, et al., 2014; van Mechelen, Van Mechelen, & Verhagen, 2013), and have all the information at the moment (Macedo, Madeira, Correia, & Jardim, 2014).

There were several limitations to this study. Information bias may arise when the method of collecting information differs between groups or raters. The limitations of our work arise from the difficult nature of its objective, which is to measure the interaction of different factors that may be involved in measuring strength training related injuries. The questionnaire's sample size and its practical applications, however, are its most obvious strengths. This study attempted to reduce information bias by ensuring that the measurement instrument under development was subjected to a rigorous face, content, and criterion validity process. Measures devised to minimize the possibility of systematically incorrect results plus validation procedures were the standardization of injury definition, data collection forms, instructions, and information.

The present study revealed promising findings regarding the implementation of a specific strength training injury questionnaire and in addition, the new technologies like text messaging, app mobile and website could be a feasible and reliable tool for registration of injuries and exposure.

ACKNOWLEDGEMENTS

The PRONAF Study takes place with the financial support of the Ministerio de Ciencia e Innovación, Convocatoria de Ayudas I+D 2008, Proyectos de Investigación Fundamental No Orientada, del VI Plan de Investigación Nacional 2008-2011, (Contract: DEP2008-06354-C04-01).

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