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# 1 Development and validation of the Sports Supplements Beliefs Scale

## 3 Abstract

4 It has been proposed that the use of sports supplements by athletes might lead to the use of banned  
5 substances. This has been termed the gateway hypothesis. Given this hypothesis, if we accept that athletes use  
6 non-banned sports supplements because they believe that they will be effective, a measure of athletes' beliefs  
7 about supplements might allow practitioners to identify athletes at risk of doping. We report the five-stage  
8 development of the Sports Supplements Beliefs Scale (SSBS). In study 1 we evaluated athletes' beliefs about  
9 sports supplements by conducting semi-structured interviews on 16 athletes. Inductive and deductive analyses  
10 resulted in a pool of 26 items. In study 2 we recruited a panel of experts and athletes to evaluate the content  
11 validity of the 26 items. 15 items were eliminated at this stage. In study 3 we subjected the responses of 171  
12 athletes to exploratory factor analysis to determine the factor structure of the scale. A two-factor model  
13 emerged, with one strong six-item factor, a less coherent four-item factor, and one item that cross loaded. In  
14 study 4, responses of a sample of 412 team sports athletes were subjected to confirmatory factor analysis. Of  
15 three competing models tested, a six-item single-factor model demonstrated best model fit ( $\chi^2/df = 2.894$ ,  
16 RMSEA = 0.068; 90% CI = 0.038 to 0.099,  $P = 0.146$ , SRMR = 0.0246, CFI = 0.987, TLI = 0.978, AIC = 50.045, EVCI  
17 = 0.122). Factor loadings ranged from 0.4 and 0.9. All  $t$ -values were statistically significant ( $P < 0.001$ ) and  
18 ranged from 10.3 to 13.3. In study 5 we examined relationships between scores on the six-item scale and  
19 supplement use. Linear regression indicated that higher scores were significantly associated with the use of a  
20 greater number of supplements ( $\beta = 0.534$ ,  $P < 0.001$ ,  $r^2 = 0.285$ ) and higher frequency of supplement use ( $\beta = -$   
21  $0.517$ ,  $P < 0.001$ ,  $r^2 = 0.267$ ). Scores of users and non-users of supplements differed significantly (mean  
22 differences =  $6.37 \pm 0.56$ ,  $U = 8,357$ ,  $P < 0.001$ ), with discriminant function analysis indicating that scores  
23 correctly predicted 76% of sport supplement users and 66% of non-users (Wilks Lambda = 0.760  $\chi^2 = 110.988$ ,  $P$   
24  $< 0.001$ ). Whilst future research will be required to demonstrate its predictive validity, the SSBS has utility in the  
25 assessment of athletes' beliefs about sports supplements. In the context of the gateway hypothesis, SSBS  
26 scores might play a meaningful role in identifying at risk athletes and in evaluating interventions.

27 Key words: anti-doping; athletes; drugs; factor analysis.

## 28 1.1 Introduction

29 Doping, the use of banned substances by athletes, undermines the ethos of sport and can place the health of  
30 athletes at risk. To deter doping, national anti-doping agencies devote substantial resources to detecting and  
31 punishing athletes who are using banned substances, with up to 250,000 tests conducted annually (Pound,  
32 Ayotte, Parkinson, Pengilly, & Ryan, 2012). However, analytical findings of drug tests have remained the same  
33 for the past 10 years, with only ~1-2% of tests showing a positive result. The World Anti-Doping Agency has  
34 thus endorsed a preventative approach (World Anti-Doping, 2015) with many researchers seeking to identify  
35 the psychological risk factors for doping (see Ntoumanis et al., 2014 for review) that might inform policy.

36 In relation to the last point above, it has been proposed that the use of non-banned sport supplements such as  
37 caffeine, creatine and sodium bicarbonate, might be a risk factor for doping. In short, the use of non-banned  
38 substances can lead to the use of banned substances. In a recent meta-analysis (Ntoumanis et al., 2014), the  
39 strongest correlate of doping behaviour was the use of sport supplements. Sports supplements are widely used  
40 by athletes of all ages and abilities (Knapik et al., 2016), with the aim of enhancing performance, recovery,  
41 and/or other sport related factors (Nieper, 2004; Maughan, King, & Lea, 2004; Lun, Erdman, Fung, & Reimer,  
42 2012).

43 The idea that use of non-banned and arguably safe substances by athletes might lead to the use of banned and  
44 potentially unsafe ones is provocative. However, several hypotheses might explain this association. Thorndike's  
45 (1911) 'law of effect,' suggests that the probability of a response being made is increased when followed by a  
46 reward and decreased when followed by discomfort. An athlete using a sport supplement for the first time is  
47 likely to attribute any potential improvements (or decrements) in performance to the supplement, with  
48 improvements in the athlete's performance suggested to increase the likelihood of future supplement use and  
49 decrements suggested to decrease this. Further positive experiences of supplementation reinforce the belief  
50 that the supplement is effective, and negative experiences reinforce the belief that the supplement is  
51 ineffective. The response to the supplement is thus reinforced by the outcome in performance. This is  
52 underpinned by Pavlovian conditioning, where a stimulus (i.e. sport supplement) is associated with a response  
53 (i.e. improvement in performance), which can reinforce the substances effectiveness (Everitt & Robbins, 2013).  
54 These experiences can create cues that embody affective states and strengthen the association between the  
55 response and the stimuli (Stewart, De Wit, & Eikelboom, 1984). The conditioned effects of a substance can  
56 activate neural mechanisms that mimic the neural activity of the substance, and it is the activation of these  
57 states by conditioned stimuli that initiates further substance use behaviour (Everitt & Robbins, 2005; 2013).  
58 However, with repeated exposure of a substance, the pharmacological effects are often markedly reduced over  
59 time and the brain systems that are normally involved become desensitised to the physiological effects, but  
60 more significantly, become hypersensitive to the associated stimuli (Hyman & Malenka, 2001). Sensitisation of  
61 substances may lead to an increased use of the same substance or use of another, stronger, substance; a  
62 process termed 'cross-sensitisation' (Robinson & Berridge, 1993).

63 Whilst it is clear that numerous hypotheses might explain the progression to strong drugs through the use of  
64 weaker ones, the term 'gateway hypothesis' has been used as a coverall. Originally credited to Kandel, (1975),  
65 the gateway hypothesis proposes that individuals become increasingly involved in drugs in stages and in  
66 sequences. Kandel (1975) reported that if adolescents progress to marijuana use, the likelihood of using harder  
67 illicit drugs, such as cocaine and heroin, would significantly increase from 2 and 3% to between 16 and 23%.  
68 More recent epidemiological data report that 56.3% and 84.5% of high school students would smoke tobacco  
69 or drink alcohol before progressing to marijuana and cocaine respectively (Johnston, O'Malley, Miech,  
70 Bachman, & Schulenberg, 2013). Further evidence from the Substance Abuse and Mental Health Services  
71 Administration (2013) revealed that 65% of marijuana users started smoking or drinking before they started  
72 using marijuana, whilst 97% of cocaine users started smoking or drinking before progressing to cocaine.  
73 Fergusson & Horwood (2000) reported that over 99% of illicit drug users in New Zealand would use cannabis  
74 first before progressing to other illicit drugs and Prince van Leeuwen et al. (2013) reported that tobacco use in  
75 the Netherlands was associated with a higher likelihood of developing a marijuana use disorder.

76 Although the above epidemiological evidence has arguably established a weak drug-strong drug sequence in  
77 which different substances are used, it has not identified what causes the progression from one drug to the  
78 next. For this reason, many authors have criticised the validity of the gateway hypothesis and its causal  
79 mechanisms (Vanyukov et al., 2012; Kleinig, 2015). However, animal studies have shown that the intake of a  
80 'softer' drug can increase the intake of a 'harder' drug; for example animals sensitised to amphetamines have  
81 shown an increased intake of cocaine (Ferrario & Robinson, 2007), whilst animals given access to sugar

82 increase the intake of alcohol (Avena, Carrillo, Needham, Leibowitz, & Hoebel, 2004) and cross-sensitise to  
83 cocaine (Gosnell, 2005). Levine et al. (2011) proposed a molecular explanation for the gateway hypothesis and  
84 the sequence of drug use, suggesting that exposure to nicotine causes specific changes in the brain that make it  
85 more vulnerable to cocaine addiction. It was also shown that pre-treatment with nicotine greatly alters the  
86 response to cocaine in terms of addicted related behaviour and changes in brain regions critical for addiction  
87 related rewards. Furthermore, and at a molecular level, nicotine enhanced the effect of cocaine when it was  
88 administered for several days prior to the use of cocaine. These results stimulated further analysis of  
89 epidemiology data, where Kandel & Kandel (2014) reported cocaine users would often start using cocaine only  
90 after prolonged smoking of tobacco. Collectively, data suggest that in the general population in Western  
91 societies, there is a well-defined sequence of progression of drug use. That is illicit drug use often starts with a  
92 softer drug and proceeds to harder drug use. The idea of the gateway hypothesis has influenced US drug policy  
93 since the 1950's (Morral, McCaffrey, & Paddock, 2002).

94 Whilst the sport-specific database is less well developed than the substance use literature, it is proposed that  
95 in a manner similar to that in which the use of legal recreational drugs (e.g., alcohol and nicotine) leads  
96 progressively to the use of stronger illegal drugs in the general population, the use of sport supplements by  
97 athletes might lead to the use of stronger and often banned substances (Lentillon-Kaestner & Carstairs, 2010;  
98 Hildebrandt, Harty, & Langenbucher, 2012).

99 The available research in sport is based on the testimony of athletes, and not on experimental or  
100 epidemiological data. Furthermore those testimonies are in relation to a contentious subject, so cannot be  
101 described as entirely unproblematic (for example, it is as plausible that athletes who dope use supplements to  
102 optimise drug effects as it is that athletes who use supplements go on to dope). It must also be made clear that  
103 as is the case with progression from alcohol and marijuana, for example, progression from sport supplements  
104 to doping substances is far from inevitable. However, given both the physiological and epidemiological  
105 evidence above, and given that there is no reason to suggest that sport represents a special case in relation to  
106 substance use, the gateway hypothesis represents a plausible mechanism and warrants further investigation.

107 As suggested above, anti-doping agencies seek methods to identify athletes more susceptible to doping.  
108 Although still a developing field, the main focus of this work has been involved with the development and  
109 validation of psychometric measures that sufficiently identify and quantify psychological constructs of doping  
110 behaviours (Petróczi et al., 2015). However, obtaining reliable self-report information about *explicit* doping  
111 behaviours is associated with several ethical and practical challenges, including the considerable problem that  
112 an admission of use of a banned substance can result in the athlete losing their right to participate in sport. For  
113 this reason, researchers generally use one or more psychological constructs as a proxy to doping behaviour. To  
114 date, the validated psychological methods used have mainly focused on quantifying athletes' attitudes towards  
115 doping (e.g. Petróczi & Aidman, 2009; Brand, Melzer, & Hagemann, 2011). Athletes reporting more favourable  
116 attitudes towards banned substances are predicted to be more likely to initiate the behaviour. Other cognitive  
117 variables, for example moral disengagement, sport orientation and task and ego orientation, have also been  
118 used to describe an athletes doping mindset (Petróczi et al., 2015).

119 Recent data suggest that athletes who use sport supplements tend to express more favourable beliefs about  
120 the effectiveness of these types of substances compared to non-users (Backhouse et al., 2013). Furthermore,  
121 athletes' beliefs about sport supplements influence future behaviours and intentions (Bell, Dorsch, McCreary,  
122 & Hovey, 2004). Hypothetically therefore, if athletes' beliefs about sports supplements influence current and  
123 future supplement use, and if current/future supplement use predicts future doping, it is reasonable to suggest  
124 a relationship between current beliefs about supplements and future doping. Given this, an instrument  
125 facilitating the reliable and valid assessment of beliefs about supplements could represent a useful tool in the  
126 development and evaluation of anti-doping interventions. To our knowledge no validated measure of athletes'  
127 beliefs about sport supplements has been published.

128 Mazanov 2016) emphasised that authors reporting data of relevance to doping should explicitly state their  
129 biases and research aims. Our position is that anti-doping policy is absolutely necessary to both protect the  
130 integrity of sports, which are after all defined by their rules, and even more importantly, to ensure the health  
131 and wellbeing of athletes. We argue that detection and deterrence methods used by anti-doping authorities  
132 are often ineffective and/or draconian (Dimeo, 2016). We value a preventative approach that places emphasis  
133 on providing athletes with education, information and strategies to inform and support their decision to not  
134 use banned performance enhancing substances. Given the possible relationships between athletes' beliefs

135 about sport supplements and doping, the aim of this study was to develop and validate a psychometric  
136 measure that might identify at-risk athletes.

137 Below we report the multi-stage validation of such a measure that could facilitate future research investigating  
138 the psychological underpinnings of substance use behaviours. Anastasi and Urbina (1997) argue that the  
139 validation of any psychometric instrument requires multiple procedures, which are employed sequentially at  
140 different stages of construction. Validity is thus built into the test at the outset rather than being limited to the  
141 last stages of test development, as in traditional criterion-related validation. Each of these procedures/stages  
142 can be seen as fundamental to demonstrating the two sources of information described by Murphy and  
143 Davidshofer (1998) as representing strong evidence for the validity of measurement, that is, content and  
144 construct validity. Murphy and Davidshofer proposed that the empirical and theoretical basis for the construct,  
145 the interpretability of that construct, the generalisability of the construct definition, and the applicability of the  
146 initial item pool to that definition, all jointly determine the content validity of the questionnaire. Similarly, the  
147 results of empirical item analyses, factor analyses, and criterion analyses jointly indicate construct validity.

148 In line with the proposals above, we report the results of semi-structured interviews exploring athletes' beliefs  
149 about sport supplements (study 1), initial instrument development and content validity procedures (study 2),  
150 exploratory and confirmatory factor analyses of responses to the questionnaire from  $n=171$  and  $n=412$  athletes  
151 respectively (studies 3 and 4), and relationships between questionnaire scores and supplement use (study 5).  
152 Our institutional research ethics committee approved all studies. Informed consent was obtained from each  
153 participant in each of the studies prior to their involvement.

## 154 **Study 1**

### 155 **2.1 Aims**

156 We aimed to explore and demonstrate the empirical basis for the questionnaire through the identification of  
157 themes and dimensions relating to the use of sports supplements by athletes.

### 158 **2.2 Method**

159 DeVellis (2012) and Lynn (1995) recommend that in questionnaire development, core concepts be identified  
160 using qualitative interviews. We therefore used semi-structure interviews to explore athletes' beliefs about  
161 sports supplements.

162 *2.2.1 Participants.* Sixteen athletes (6 females and 10 males; age =  $24 \pm 3$ ; years training =  $10 \pm 4$ ; hours per  
163 week training =  $13 \pm 4$ ), were recruited via social media. To ensure that responses were not affected by specific  
164 sport cultures and practices, athletes of varying abilities were recruited from various sports including football,  
165 gymnastics, mixed martial arts, rowing, Rugby union, track and field and weightlifting. Participants had a range  
166 of athletic experience, with 13% competing at club level, 19% at county, 19% at regional, 25% at national and  
167 25% at international.

168 *2.2.2 Procedure.* Each athlete was interviewed individually by the lead author either face-to-face or via Skype.  
169 Initially adopting a deductive approach, an interview guide based upon the available literature was developed.  
170 However, the semi-structured interview schedule was developed to be sufficiently flexible to allow new  
171 concepts to surface inductively (Ntoumanis, Pensgaard, Martin, & Pipe, 2004).

172 Athletes were asked to describe their decisions for using or not using sport supplements, the factors that  
173 influenced these decisions, and any experiences of using sport supplements. The semi-structured interviews  
174 consisted of a series of questions of four interrelated sections: 1) what is a sport supplement; 2) experiences of  
175 sport supplements; 3) beliefs about sport supplements and 4) influences to use sport supplements. Interview  
176 times ranged from 36 to 91 minutes (mean  $\pm$  SD =  $56 \pm 21$  minutes). All participants had the right to stop the  
177 interview and/or participation at any time. All participants were emailed a copy of the transcript to enable  
178 them to revise responses. Data analyses began only after the athlete accepted the final version of the  
179 transcript.

180 *2.2.3 Data analysis.* Audio recordings were transferred onto the software QSR NVivo 10. The lead investigator  
181 read each transcript several times to familiarise himself with the data. This process allowed ordinate and sub-  
182 ordinate themes to emerge. Both deductive and inductive approaches to thematic analysis were used. Data  
183 analysis followed a three-stage coding process adapted from Smith et al., (2010): first, a summary report of the  
184 individual interviews to highlight the most pertinent issues; second a pool of narratives centred on specific  
185 ordinate themes; and third, a thematic grouping structure around sub-ordinate themes.

## 186 **2.3 Results**

187 A summary of the main findings is presented in table 1. Four ordinate themes emerged from the data. The first  
188 related to the performance enhancing effects of sport supplements, contained three sub-ordinate themes:  
189 improved performance, higher chance of winning, and competitive edge. A second ordinate theme related to  
190 athletes' perceptions that sport supplements could help improve recovery and health, also contained three  
191 sub-ordinate themes: improved recovery, overcoming illness, and reduced chance of injury. A third ordinate  
192 theme related to athletes' perceptions that sport supplements were necessary for performance, and contained  
193 two sub-ordinate themes: performance advantage, and the similarity between the use of supplements and the  
194 use of up-to-date equipment. A final ordinate theme related to the psychological effects associated with sport  
195 supplement use, contained two sub-ordinate themes: confidence and anxiety.

## 196 **Study 2**

### 197 **3.1 Aims**

198 We aimed to develop a pool of items derived from responses to study 1 and to demonstrate the content  
199 validity of these.

### 200 **3.2 Method**

201 Based on responses reported in study 1, we developed a pool of 26 items. Subsequently a panel of experts and  
202 athletes assessed the content validity of the resultant measure.

203 *3.2.1 Participants.* Participants were a sample of six experts on anti-doping and 23 British athletes. Experts had  
204 all published in the anti-doping literature and were situated in Australia (n = 2), United Kingdom (n = 1), United  
205 States (n = 1), Italy (n = 1) and Canada (n = 1). Athletes (57% male, years training =  $11 \pm 6$ , hours per week  
206 training =  $9 \pm 6$ ) were of a variety of ages, the majority aged between 18 and 24 (48%). Athletes competed at  
207 various levels, with county being most common (48%), followed by national (35%), international (13%) and club  
208 (4%). Athletes were drawn from a variety of sports including track and field, weightlifting, triathlon, Rugby  
209 union, field hockey and badminton. No participants from study 1 were recruited to study 2.

210 *3.2.2 Procedures.* We developed an online survey to enable academic experts to assess content validity and  
211 sent individual emails to a number of experts worldwide requesting their participation. We provided experts  
212 with the 26 items and asked them to respond on a 4-point Likert type-scale (1 = not relevant; 4 = highly  
213 relevant) as to how they believed each item related to athletes' beliefs about sport supplements. Free-text  
214 boxes for each item facilitated comments, as did a similar free-text box at the end of the scale. Participants had  
215 a range of athletic experience, with 13% competing at club level, 19% at county, 19% at regional, 25% at  
216 national and 25% at international.

### 217 **3.3 Results**

218 We summarised expert ratings of content validity by dividing the number of experts who provided a rating of 3  
219 or 4 by the total number of experts (Lynn, 1986). Lynn proposed that when six or more experts review the  
220 content validity index (CVI) of a scale, values equal to or greater than 0.8 are acceptable (see also Polit, Beck, &  
221 Owen, 2007). CVI values of less than 0.8 were evident for seven items and these were removed from further  
222 analysis.

223 Athletes reported that the items adequately represented their beliefs about sport supplements. However,  
224 athletes reported that certain types of sport supplements do not elicit specific performance effects and  
225 suggested that the type of supplement they used influences their belief about its effects. For example, athletes  
226 who used protein drinks did not believe that this type of supplement would influence performance, but did  
227 believe that it would improve recovery. Based upon these comments, we deleted eight items relating to  
228 specific performance enhancing effects of sport supplements (e.g., fatigue, pain, recovery). A final pool of 11  
229 items remained.

## 230 **Study 3**

### 231 **4.1 Aims**

232 Following content validity procedures, we examined the factor structure of the 11-item measure. Factor  
233 analysis is a statistical procedure applied to a single set of variables where the researcher is interested in  
234 discovering which variables in the set form coherent subsets that are relatively independent of each other.

235 Essentially, the aim of factor analysis is to reduce a large number of variables to a smaller number of factors  
236 (Tabachnick & Fidell, 2007), and to indicate how many factors are needed to describe the data.

237 Exploratory factor analysis (EFA) is an inductive process that in essence 'explores' the data, and results in a set  
238 of latent variables that explain correlations among the measured, or manifest, variables. Marsh and Yeung  
239 (1997) argued that "a long history of factor analytic research has demonstrated that this purely exploratory  
240 approach to factor analysis is typically ineffective" (p. 33), and Hendrickson and Jones (1987), in an often-cited  
241 phrase, suggested that EFA is no more than "an undisciplined romp through a correlation matrix" (p. 105). As a  
242 consequence of its limitations, it has been proposed that EFA is appropriate only when the analyst does not  
243 know what the underlying factor structure of a set of data should be (Biddle, Markland, Gilbourne,  
244 Chatzisarantis, & Sparkes, 2001). Several authors (Anastasi & Urbina, 1997; Marsh & Yeung, 1997; Schutz, 1994;  
245 Schutz & Gessaroli, 1993; Tabachnick & Fidell, 2007) proposed that confirmatory factor analysis (CFA), which  
246 permits the analyst to test an *a priori* model of relationships between the manifest and latent variables, should  
247 be used in preference to EFA.

248 However, in studies 1 and 2 above we adopted an empirical and largely atheoretical approach in deriving  
249 items. We therefore posited no a-priori theory as to any potential inter-correlations between items. On this  
250 basis we believe that the optimal approach to demonstrating factorial validity would be to report the results of  
251 both EFA and CFA procedures. We therefore used EFA on a first sample of athletes and subsequently  
252 interrogated, modified and confirmed the resultant factor structure using CFA on a different sample (study 4).

## 253 4.2 Method

254 4.2.1 *Participants*. Participants were 171 athletes (67% male; years training =  $12 \pm 9$ ; hours per week training =  
255  $11 \pm 7$ ). Over 25 different sports were represented, with the highest proportions of athletes from athletics  
256 (43%), triathlon (18%), cycling (13%), and weightlifting (5%). Athletes were between the ages of 18 and 24  
257 (24%), 25 and 34 (26%), 35 and 44 (25%) and 45 or older (25%) and were of differing competitive levels with  
258 30% competing at club level, 19% county, 27% national, and 24% international. We recruited athletes via social  
259 media, and requested that they complete the questionnaire via a secure online survey platform  
260 ([www.surveymonkey.com](http://www.surveymonkey.com)).

261 4.2.2 *Procedure*. Athletes' completed the newly developed 11-item instrument, which was labelled the 'Sport  
262 Supplements Belief Scale' (SSBS). The SSBS required athletes to respond on a 6-point Likert-type scale with  
263 scores ranging from strongly disagree (1) to strongly agree (6). We used a Likert-type scale following Comrey's  
264 (1988) recommendations that multiple-choice scales are more reliable and produce better scales than other  
265 formats (e.g., visual analogue scales, checklists).

266 4.2.3 *Data analysis*. We inputted data into SPSS v22.0. A missing values analysis indicated that of a possible  
267 1881 data points only 15 (0.7%) were missing from 12 respondents (8%). No respondents had less than 5% of  
268 missing data and Little's MCAR test revealed data were missing completely at random ( $\chi^2 = 146.093$ ,  $df = 50$ ,  $P =$   
269  $0.957$ ). We replaced missing values using a multiple imputation model that generated five data sets with a  
270 maximum number of parameters set at 100. The average value of the missing data sets was used for the  
271 subsequent analysis.

272 We used EFA with the Maximum Likelihood method to examine the dimensionality of responses to items.  
273 Sample size recommendations for EFA vary, but given that 5-10 participants per item are considered  
274 acceptable (Bentler & Chou, 1987), the sample size of 171 for the 11 items is adequate. We used oblique  
275 (promax) rotation, as we anticipated correlation among factors. Factors with eigenvalue greater than 1 were  
276 extracted, primary loadings of 0.3 or above were considered interpretable, and loadings 0.4 or above  
277 considered important (Hair, Black, Babin, & Anderson, 2006). We excluded any item associated with a loading  
278 below 0.3. We report Cronbach's alpha to indicate the internal consistency of the scale, with adequate  
279 reliability demonstrated at levels above 0.7 (Nunnally, 1978).

## 280 4.3 Results

281 A two-factor model emerged. Item 10 'Using supplements makes me optimistic about my performance' cross-  
282 loaded, so we removed this item and repeated the procedure with 10 items. Once again a two-factor model  
283 emerged with an explained variance of 48.83%. Factor 1 (7-items) appeared to describe the beliefs of athletes  
284 regarding the outcomes of using supplements themselves, whilst Factor 2 (3-items), although less clear, could  
285 be interpreted as normative beliefs of athletes about supplements, that is, athletes' perceptions that  
286 supplements are an accepted means of performance enhancement. Bartlett's test of sphericity was significant,

287  $\chi^2 = 490.963$ ,  $df = 15$ ,  $P < 0.001$  and the Kaiser-Meyer-Olkin statistic was considered good (0.884). The 10 items  
288 and their respective factor loadings are presented in table 2.

## 289 **Study 4**

### 290 **5. 1 Aims**

291 The penultimate stage of the early development and validation process was to assess the factor structure of  
292 the instrument using confirmatory factor analysis (CFA).

### 293 **5.2 Method**

294 Confirmatory factor analysis is a statistical procedure for testing theory. As such it contrasts with EFA in that in  
295 CFA, the test developer specifies the item-to-factor loadings in advance and assesses the 'goodness of fit'  
296 between this model and the reported data. The principal indicator of good model fit is a small and non-  
297 significant  $\chi^2$  (Biddle et al., 2001). However, it is often unclear whether a significant  $\chi^2$  is the result of poor fit or  
298 large sample size (larger samples tend to produce larger values of  $\chi^2$  that are also more likely to be significant,  
299 i.e., a Type I error, whereas small samples may accept poor models, i.e., a Type II error). To moderate the  
300 effects of sample size on model fit, several authors have recommended that the  $\chi^2$  to degrees of freedom ratio  
301 be used in preference to  $\chi^2$  alone (e.g. Heene, Hilbert, Draxler, Ziegler, & Bühner, 2011; Marsh, Balla, &  
302 McDonald, 1988) whilst others have suggested that authors rely on other types of fit indices (Byrne, 1998; Hu  
303 & Bentler, 1999). These include Comparative Fit Index (CFI); Root Mean Square Error of Approximation  
304 (RMSEA); Standardized Root Mean Squared Residual (SRMR); Tucker-Lewis Index (TLI), Akaike Information  
305 Criterion (AIC) and the Expected Cross-Validation Index (ECVI).

306 *5.2.1 Participants.* Four hundred and sixty-eight competitive male and female athletes (81% male, years  
307 training =  $10 \pm 6$ , hours per week training =  $6 \pm 4$ ) volunteered to participate in the study. Over 12 different  
308 sports were represented, with the highest proportions of athletes from Rugby union (54%), football (23%),  
309 hockey (5%), and American football (4%). Athletes were between the ages of 18 and 24 (64%), 25 and 34 (24%),  
310 35 and 44 (4%) and undisclosed (8%) and were of differing competitive levels with 23% competing at club level,  
311 32% county, 26% national, 10% international and 9% undisclosed.

312 *5.2.2 Procedure.* We asked athletes to complete the ten-item questionnaire reported in study 3. Athletes were  
313 required to read and respond to each statement on a 6-point Likert-type scale ranging from strongly disagree  
314 (1) to strongly agree (6). All statements were scored in the same direction and total scores ranged from 10 to  
315 60.

316 *5.2.3 Data analysis.* We inputted data into SPSS v22.0 and Amos v22.0. Examination of data revealed that 16  
317 respondents did not respond to any of the items on the scale and were thus deleted. A further 40 respondents  
318 were removed after examination of the data revealed they were unengaged (i.e., responses were coded the  
319 same for each item). A missing values analysis indicated that, of a possible 2,652 data points, only 8 (0.17%)  
320 were missing from 8 respondents (1.8%). Little's MCAR test revealed data were missing completely at random  
321 ( $\chi^2 = 25.775$ ,  $df = 24$ ,  $P = 0.365$ ). Missing values were replaced using a multiple imputation model that generated  
322 five data sets with a maximum number of parameters set at 100. The average value of the missing data sets  
323 was used for subsequent analysis.

324 We examined measurement model fit using CFA and the Maximum Likelihood procedure on AMOS v22.0.  
325 Model fit was expressed as acceptable when the ratio between chi-square statistic and the degrees of freedom  
326 ( $\chi^2/df$ ) ranged between 1 and 3 (Kline, 2011). The overall fit of the model was also assessed with the RMSEA,  
327 SRMR, CFI, and TLI. Model fit was considered acceptable with values of RMSEA close or less than 0.06, of SRMR  
328 close to or less than 0.08, and of CFI and TLI close to or greater than 0.95 (Hu & Bentler, 1999). The AIC and  
329 ECVI do not have a specified acceptable value, but the lower the value amongst competing models is  
330 considered to be the most parsimonious and most likely to be replicated by other samples. Finally, to  
331 determine the significant parameter estimates, we calculated  $t$ -values by dividing the factor loading by the  
332 standard error. We classified  $t$ -values exceeding 1.96 and 2.56 as significant at the 0.05 and 0.01 level  
333 respectively (Suhr, 2006).

334 As per published recommendations (Bentler, 2006), each hypothesised relationship between the latent factor  
335 and factor loadings was a free parameter, with the exception of a single item that was randomly assigned to  
336 unity to define the scale of the factor.

### 337 **5.3 Results**



338 Mean scores on the ten-item SSBS were  $31.69 \pm 9.59$ . Scores ranged from 11 to 59, with increasingly higher  
339 scores representing increasingly positive beliefs relating to sports supplements.

340 CFA of a two-factor, ten-item model revealed inadequate fit ( $\chi^2/df = 3.832$ , RMSEA = 0.083; 90% CI = 0.068 to  
341 0.098,  $P < 0.001$ , SRMR = 0.0731, CFI = 0.950, TLI = 0.934, AIC = 172.304, ECVI = 0.419). After examination of  
342 the scale we suspected that a single-factor, unidimensional scale, might improve model fit. The second factor  
343 of three items was therefore removed and the CFA was performed once more.

344 CFA of a single-factor seven-item model indicated improved model fit ( $\chi^2/df = 3.239$ , RMSEA = 0.074; 90% CI =  
345 0.05 to 0.098,  $P = 0.047$ , SRMR = 0.0309, CFI = 0.978, TLI = 0.968, AIC = 73.349, ECVI = 0.178). However,  
346 modification indices revealed large overlap between item 1 ('Supplements improve my training') and item 7  
347 ('Training increases the need for supplements'). As the items related to similar theoretical constructs, item 7  
348 was removed.

349 CFA on a single-factor six-item scale indicated acceptable loadings for all indices ( $\chi^2/df = 2.894$ , RMSEA = 0.068;  
350 90% CI = 0.038 to 0.099,  $P = 0.146$ , SRMR = 0.0246, CFI = 0.987, TLI = 0.978, AIC = 50.045, ECVI = 0.122). The  
351 results of the final model are summarised in table 3 and factor loadings with standard errors are shown in  
352 figure 1.

## 353 **Study 5**

### 354 **6.1 Aim**

355 We aimed to demonstrate tentative construct validity of the SSBS through the examination of relationships  
356 between SSBS scores and self-reported supplement use.

### 357 **6.2 Method**

358 Murphy and Davidshofer (1998) argued that, whilst in the past validation strategies were distinct, that is  
359 information relating to predictive, discriminant, concurrent, and construct validity would be presented  
360 separately, researchers increasingly recognise that all validation procedures can be grouped under the heading  
361 of construct validity.

362 *6.2.1 Participants.* SSBS scores collected from the participants in study 4 were used in this study. We also asked  
363 participants to respond to a series of questions relating to the range of supplements they use and to the  
364 frequency of use.

365 *6.2.2 Data analysis.* We used linear regression to examine relationships between SSBS scores and both the total  
366 number of sport supplements used and frequency of use (i.e., daily, weekly, monthly and never). We used  
367 Mann-Whitney U tests to compare total SSBS scores of users and non-users of sport supplements followed by  
368 discriminant function analysis to determine the degree to which SSBS scores might predict which athletes fell  
369 into one of two groups; users of supplements and non-users of supplements. Finally, Cronbach's alpha was  
370 calculated to provide an indication of internal consistency.

### 371 **6.3 Results**

372 A Kolmogorov Smirnov test indicated that data violated normality ( $P < 0.05$ ). Linear regression indicated  
373 significant relationships between SSBS scores and supplement use. Specifically, higher SSBS scores were  
374 significantly associated with the use of greater variety of supplements ( $\beta = 0.534$ ,  $P < 0.001$ ,  $r^2 = 0.285$ ). Likewise  
375 higher SSBS scores were significantly related to higher frequency of supplement use ( $\beta = -0.517$ ,  $P < 0.001$ ,  $r^2 =$   
376  $0.267$ ).

377 We assessed differences in SSBS scores of users and non-users using a Mann-Whitney U test. Users reported  
378 significantly higher SSBS scores than non-users (mean differences =  $6.37 \pm 0.5$ ,  $U = 8,357$ ,  $P < 0.001$ , figure 2).  
379 Discriminant function analysis indicated that SSBS scores correctly predicted 76% of sport supplement users  
380 and 66% of non-users (Wilks Lambda = 0.760  $\chi^2 = 110.988$ ,  $P < 0.001$ ). Tests of equality between groups were  
381 significant though ( $P < 0.001$ ). Cronbach's alpha of 0.891 indicated good internal consistency of the six-item  
382 scale.

## 383 **7.1 General discussion**

384 The gateway hypothesis predicts that athletes who use supplements are more likely to use banned substances.  
385 Given the demand characteristics inherent in any attempt to assess beliefs about banned drugs, a measure of

386 beliefs relating to supplements might have utility in both predicting at-risk athletes and in verifying the  
387 effectiveness of interventions.

388 Above we reported the empirical five-stage development of the Sports Supplements Beliefs Scale, in which  
389 multiple methods were used to generate, synthesise, evaluate and test increasingly more parsimonious  
390 versions of the instrument. From this a brief, single-factor measure with six items emerged: 'Supplements  
391 improve my performance', 'Supplements are necessary for me to be competitive', 'Supplements improve my  
392 confidence', 'My chances of winning improve when I use supplements', 'Supplements help me realise my  
393 potential', and 'Supplements improve the quality of my training'. These six items formed a theoretically and  
394 statistically coherent scale relating to athletes' beliefs about the effects of supplements on their own  
395 performance and performance related constructs. Many items that were eliminated in studies 2 and 3  
396 assessed, for example, respondents' beliefs relating to the effects of supplements on elite athletes, beliefs  
397 about specific supplements and normative beliefs. The resultant scale appears to tap into athletes' personal  
398 perspective on the effects of supplements on themselves.

399 Scores on the SSBS were associated with both the frequency and volume of supplement use among n=412  
400 athletes. Theoretically therefore, given the gateway hypothesis, high scores on the SSBS might predict athletes  
401 at risk of doping. This has several implications for intervention and education efforts targeting the use of sport  
402 supplement and doping behaviours. For example, National Anti-Doping Organisations (NADO) typically pursue  
403 a multifaceted approach in their education methods, where the aim is to cover a range of topics such as the  
404 values of sport, the testing procedures, medications and therapeutic use exemption forms (e.g. WADA's  
405 Athlete Learning Program about Health and Anti-Doping, UKAD's 100% me programme and USADA's true sport  
406 community-based movement). This often leaves only a small portion of the intervention to the discussion of  
407 sport supplements. For an athlete that scores high on the SSBS, a greater proportion of time may be needed to  
408 discuss the issues related to sport supplements. To improve the effectiveness and efficiency of the education  
409 interventions delivered, the NADO could instead target athletes who score highly on the SSBS and provide a  
410 more individual and in-depth intervention. Targeting the behaviour at this stage could also improve the  
411 effectiveness of anti-doping education. As the consumption of sport supplements arguably creates a  
412 psychological and physiological need for further, stronger substances of the same type, athletes experimenting  
413 with chemically active supplements may experience no ill effects. This would appear to contradict and  
414 undermine the strong negative publicity directed at doping. The advice and education athletes receive in the  
415 future may then become less persuasive and could increase rather than reduce the number of athletes moving  
416 onto doping substances, undermining the interventions in place by NADO's and WADA (Pudney, 2003).  
417 Educating athletes about sport supplementation may therefore prevent athletes from progressing to doping  
418 substances and improve the interventions NADO's and WADA implement.

419 It is reasonable to argue that interventions aimed at reducing athletes' confidence in, and reliance on, sports  
420 supplements might also reduce their likelihood to dope. This might happen via a direct belief-based pathway,  
421 that is, modifying an athlete's beliefs about supplements might at the same time modify that athlete's beliefs  
422 about doping. Alternatively it might result from an indirect behavioural pathway, that is, by modifying the  
423 athlete's behaviours in relation to supplements, for example their adopting non-natural forms of nutrition such  
424 as pills and powders, we might reduce the chance of those behaviours leading to a search for more effective  
425 substances. Either way, we argue that the SSBS will have utility in evidencing the effectiveness of such  
426 interventions.

427 Furthermore, the SSBS could be used within the battery of self-report instruments researchers use to  
428 understand athletes' doping behaviours. Doping is often viewed as a complex and multifaceted psychological  
429 phenomenon, where beliefs, desires, intentions, attitudes and perceptions of others, for example, can all  
430 intertwine and determine whether an athlete will decide to use banned substances or not (Hauw & McNamee,  
431 2014). Researchers generally agree that there is no single factor that predisposes an individual to use banned  
432 substances and the gateway hypothesis is just one factor to consider within the realm of anti-doping  
433 interventions. For future research aiming to understand and uncover the influences of doping behaviours, the  
434 SSBS could be used alongside other instruments to generate a more complete picture of doping behaviours.  
435 Future work will need to evaluate the predictive validity of the SSBS by reporting the degree to which scores  
436 relate to future supplement use of athletes not currently using supplements, and whilst problematic, to doping  
437 behaviours. Future work should also aim to demonstrate the construct validity of the measure by assessing  
438 pre-post changes in SSBS scores following interventions designed to reduce athletes' reliance on and  
439 confidence in sports supplements.

440 Interestingly, the SSBS will also have utility in research investigating the effectiveness of sport supplements.  
441 Specifically it has been reported that the performance of athletes with strong beliefs in the effectiveness of  
442 sports supplements were more likely to improve following the administration of both supplements and  
443 placebos than were the performances of those with less belief (Beedie & Foad, 2009).

444

445 **8.1 References**

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## 9.1 Tables

**Table 1. Ordinate and subordinate themes derived through interview data.**

Ordinate theme	Sub-ordinate theme	Transcript example
Performance effects	Improved performance	"Supplements help me improve my performance. Whether pre, during or post competition"
	Higher chance of winning	"It's really pushing you beyond what you could normally achieve"
	Competitive edge	"I'm going to take full advantage of anything that is out there"
Recovery and health effects	Improve recovery	"I know that I need to like recover as quickly as possible and therefore... a protein shake is ideal"
	Overcome illness	"... a bit of supplementation wouldn't go a miss... I think in terms of illness"
	Reduce injury	"I tend to just have it, because... I don't want to have another injury"
Necessary for performance	Necessary to improve	"They were necessary... I felt a lot better after taking them and I felt that after a match where you feel beaten up... they were necessary"
	Same as equipment	"We are always looking for the fastest gear and the fastest kit. Supplements are just part of that"
Psychological effects	Increase in confidence	"I think it's as much confidence as well... you are maximising... you know, because recovery and preparation are as much part of the training and competitions as anything else"
	Decrease in anxiety	"I was shit scared to be honest... The preparation became a very much part of that, nutrition became definitely a safety blanket in that sense"





**Table 2. Factor structure matrix of the 10-item scale derived from exploratory factor analysis**

Item no.	Items	Factor loadings	
		Factor 1	Factor 2
1	Supplements improve my performance	0.800	
2	Supplements are necessary for me to be competitive	0.695	
3	Supplements improve my confidence	0.540	
4	My chances of winning improve when I use supplements	0.810	
5	Supplements help me realise my potential	0.725	
6	Supplements improve the quality of my training	0.830	
7	Athletes using supplements are usually the ones who medal at major championships		0.394
8	Supplements provide a greater improvement compared to a healthy diet		0.496
9	Supplements are the same as having the best equipment		0.772
10	Training increases the need for supplements	0.487	

**Table 3. Factor loadings and t-values for the six-item version of the SBSS derived through confirmatory factor analysis**

Item	Items	Factor Loading	t-value
1	Supplements improve my performance	0.652	13.306
2	Supplements are necessary for me to be competitive	0.966	12.880
3	Supplements improve my confidence	0.755	11.615
4	My chances of winning improve when I use supplements	0.463	10.289
5	Supplements help me realise my potential	0.581	11.173
6	Supplements improve the quality of my training	0.868	12.400

## 10.1 Figure captions

**Figure 1.** Single-factor model. All parameters standardised and significant ( $P < 0.001$ )

**Figure 2.** Differences in sport supplement belief scores between users and non-users. \*\* =  $P < 0.001$ .