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2 **Case Study: Using Contemporary Behaviour Change Science**
3 **to Design and Implement an Effective Nutritional**
4 **Intervention within Professional Rugby League**

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6 Running Head: 'Using Behaviour Change Science Within a Nutritional Intervention'

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Abstract

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34 Designing and implementing successful dietary intervention is integral to the role of sport nutrition
35 professionals as they attempt to positively change the dietary behaviours of athletes. High-
36 performance sport is a time-pressured environment where immediate results can often supersede
37 pursuit of the most effective evidence-based practice. However, efficacious dietary intervention
38 necessitates comprehensive, systematic and theoretical behavioural design and implementation if
39 the habitual dietary behaviours of athletes are to be positively changed. Therefore, this case study
40 demonstrates how the Behaviour Change Wheel was used to design and implement an effective
41 nutritional intervention within professional rugby league. The eight-step intervention targeted
42 athlete consumption of a high quality dietary intake of 25.1 MJ each day, to achieve an overall body
43 mass increase of 5 kg across a twelve-week intervention period. The Capability, Opportunity,
44 Motivation-Behaviour model and APEASE criteria were used to identify population-specific
45 intervention functions, policy categories, behaviour change techniques and modes of intervention
46 delivery. The resulting intervention was successful, increasing the average daily energy intake of the
47 athlete to 24.5 MJ, which corresponded in a 6.2 kg body mass gain. Despite consuming 0.6 MJ less
48 per day than targeted, secondary outcome measures of diet quality, strength, body composition and
49 immune function all substantially improved, supporting a sufficient energy intake and the overall
50 efficacy of a behavioural approach. Ultimately, the Behaviour Change Wheel provides sport nutrition
51 professionals with an effective and practical step-wise method via which to design and implement
52 effective nutritional interventions for use within high-performance sport.

53

54 **Keywords:** Behaviour Change Wheel, Nutrition, Sports Nutrition

55 **Introduction**

56 Designing and implementing successful dietary intervention is integral to the role of sport nutrition
57 professionals as they attempt to positively change the dietary behaviours of athletes. High-performance
58 sport is a time-pressured environment where necessity for immediate results can often supersede
59 pursuit of the most effective evidence-based practice (Coutts, 2017). This is apparent within
60 contemporary dietary intervention, which lacks comprehensive, theoretical or systematic behavioural
61 design and implementation (Atkins & Michie, 2015). Instead, current dietary approaches within high
62 performance sport are based upon fast, implicit, common sense models (Michie et al., 2009),
63 consistently shown to result in less effective intervention (Craig et al., 2008). Evidently, novel
64 approaches are required that provide both the scientific rigour and ease of application required for
65 nutritional interventions to be successful within the challenging environment of professional sport
66 (Jones et al., 2017).

67 The purpose of this case study was to demonstrate how the Behaviour Change Wheel (BCW; Michie et
68 al., 2014) was used to design and implement a successful nutritional intervention aimed at increasing
69 the BM of a professional male adolescent rugby league (RL) player, herein referred to as “the athlete”.

70

71 **The Athlete**

72 The athlete was an eighteen-year-old professional male adolescent RL positional centre, who had
73 recently signed a senior contract with a European Super League club. He was required to increase his
74 body mass (BM) to 90 kg before joining the first team squad. This required a 5.6 kg increase over a
75 twelve-week intervention period. The athlete was susceptible to illness and had missed a combined
76 total of 22 training days over the last five months. Previous nutritional interventions had failed to result

77 in substantial BM gains. Written informed consent was provided and ethics approval granted by Leeds
78 Beckett University, UK.

79

80 **Athlete Assessment**

81 **Anthropometric and Strength Assessment**

82 Anthropometric and strength characteristics were assessed at baseline and at the end of the twelve-
83 week intervention period. Changes in body composition were assessed by dual-energy X-ray
84 absorptiometry scans (DXA, Lunar iDXA, GE Medical Systems, UK) and sum of eight skinfold assessments
85 following standard procedures (Jones et al., 2017). Strength was assessed via three-repetition
86 maximums (3-RMs) as previously reported (Cronin & Hansen, 2005). Pre-and post-intervention values
87 are presented in Table 1.

88 **Dietary Assessment**

89 Dietary intake was measured at baseline and at the end of the twelve-week intervention period via
90 Snap-N-Send, a valid and reliable dietary assessment tool (Costello et al., 2017a; Costello et al., 2017b).
91 The four-day assessment period included two weekdays and two weekend days (Friday-Monday). Data
92 were analysed using dietary analysis software (Nutritics, Version 3.06, Dublin, Ireland). Pre- and post-
93 intervention dietary intakes are presented in Table 2 and Appendix 1.

94 **Total Energy Expenditure Assessment**

95 Resting metabolic rate (RMR) was assessed using an on-line gas analyser (Metalyzer 3BR3, Cortex,
96 Leipzig, Germany) one day prior to the start of the total energy expenditure (TEE) assessment, as
97 outlined by Compher et al. (2006). TEE was assessed over a two-week pre-season period via doubly
98 labelled water (DLW), the literature gold standard (Westerterp, 2017). The assessment period included

99 ten training and four rest days. Measured RMR was 14.7 MJ and average TEE was 22.4 MJ.day⁻¹ across
100 the two-week period. Average TEE was 24.1 MJ.day⁻¹ and 18.3 MJ.day⁻¹ on training and rest days,
101 respectively.

102

103

INSERT TABLE 1 & 2 HERE

104

105 **Design and Implementation of the Nutritional Intervention**

106 The Behaviour Change Wheel is a practical eight-step theory of behaviour change (Michie et al., 2014).

107 The core of the wheel incorporates a model of behaviour known as the COM-B (Michie et al., 2011),

108 which identifies the sources of behaviour that are important for intervention. It states that an individual

109 requires Capability (C), Opportunity (O) and Motivation (M) to perform a Behaviour (B). Surrounding the

110 COM-B are nine intervention functions (Education; Persuasion; Incentivisation; Coercion; Training;

111 Restriction; Environmental Restructuring; Modelling; Enablement) and seven policy categories

112 (Communication/Marketing; Guidelines; Fiscal Measures; Regulation; Legislation; Environmental/Social

113 Planning; Service Provision) (Michie et al., 2014). Further information regarding the nine intervention

114 functions and seven policy categories can be found in Michie et al. (2014).

115

116 **Step 1: Define the Outcome in Behavioural Terms** – The first step of the BCW involves describing the
117 intervention outcome behaviourally. As such, the outcome cannot be for the athlete to gain BM, as this
118 is not a behaviour. Correct application of this first step is essential. To drive successful dietary behaviour
119 change the intervention has to target a behavioural outcome. From baseline data, the athlete consumed
120 16.7 MJ.day⁻¹ and expended 22.4 MJ.day⁻¹. This represented an estimated 5.9 MJ.day⁻¹ deficit,

121 supporting observed symptoms characteristic of relative energy deficiency in sport (Mountjoy et al.,
122 2014, 2015). To increase BM by the desired 5.6 kg, the athlete needed to gain 0.5 kg each week and
123 therefore consume a daily energy surplus of approximately 2.1 MJ. Accordingly, a suitably defined
124 behavioural intervention targeted athlete consumption of 25.1 MJ of high quality foodstuffs each day
125 for the following twelve weeks.

126

127 **Step 2: Select A Target Behaviour(s)** – Behaviours are part of a dynamic and interactive system, they do
128 not occur in isolation (Atkins & Michie, 2015). Therefore, a long list of all the potential behaviours that
129 may affect the ability of the athlete to consume 25.1 MJ each day was developed, drawing upon
130 relevant literature (Birkenhead & Slater, 2015). This list included detailed input from the athlete and
131 significant others (i.e. parents). The list of potential behaviours was then systematically shortened.
132 Criteria developed by Michie et al. (2014) was used to identify which behaviour(s) to target: Likely
133 Impact, Ease of Implementation, Likely Spillover (i.e. collateral impact) and Ease of Measurement.
134 Applying these criteria resulted in the following five behaviours being identified;

- 135 1. Increase the knowledge of the athlete, and significant others, about the health, development
136 and performance benefits of consuming a high quality dietary intake of 25.1 MJ each day.
- 137 2. Increase the knowledge of the athlete, and significant others, about how to achieve a high
138 quality dietary intake of 25.1 MJ each day. This should specify what to eat, in what quantities
139 and at what times.
- 140 3. Provide the athlete with free and discounted high-quality food and batch-tested supplements.
- 141 4. Regularly assess the BM of the athlete. Progress should be immediately relayed back to the
142 athlete, significant others and head coach.

143 5. Provide the athlete with regular, immediate and accessible support via the cellular network.

144 It is imperative practitioners apply appropriate time to consider all population-specific relevant
145 behaviours. Choosing the wrong key target behaviours at this stage will most likely result in an
146 unsuccessful dietary intervention.

147

148 **Step 3: Specify The Targeted Behaviour(s)** – The five identified behaviours were then contextualised in
149 appropriate detail, considering;

150 - *Who* needs to perform the behaviour?

151 - *What* does the person need to do differently to achieve the desired change?

152 - *When* will they do it?

153 - *Where* will they do it?

154 This specification is provided in Table 3.

155

156

INSERT TABLE 3 HERE

157

158 **Step 4: Identify What Needs to Change** – The COM-B model was used to identify what needed to
159 change to ensure the behaviour(s) occurred. Specifically, did the athlete have both the *physical* and
160 *psychological* Capability, *physical* (i.e. environmental) and *social* (i.e. cultural) Opportunity and finally,
161 the *reflective* (i.e. evaluations and plans) and *automatic* (i.e. emotions and impulses) Motivation to
162 consume a high quality dietary intake of 25.1 MJ.day⁻¹. Each of these constructs were satisfied to ensure
163 the overall behavioural outcome was successfully achieved (Michie et al., 2014).

164 The COM-B behavioural analysis is identified in Table 3. All targeted behaviours performed by the sport
165 nutrition professional (1, 2, 4 & 5) were hindered by *physical* Opportunity (i.e. environmental
166 restrictions). Like all competent practitioners, the nutritionist had both the Capability and Motivation to
167 perform the behaviours but was limited in his Opportunity to deliver them. Whereas the club (3), was
168 hindered in their *reflective* Motivation (i.e. evaluations and plans), not Capability or Opportunity, to
169 provide an academy player with first team free food or supplement privileges. Finally, the athlete (4)
170 was hindered by his *physical* Capability (i.e. not owning weighing scales) and *automatic* Motivation to
171 consume 25.1 MJ.day⁻¹ of high quality food stuffs.

172

173 **Step 5: Identify Intervention Functions** - Having made a behavioural diagnosis via the COM-B, the next
174 step was to build the intervention. Intervention functions are broad categories of means by which an
175 intervention can change behaviour. The APEASE criteria has been developed to support function
176 selection (Michie et al., 2014);

- 177 1. Is it **A**ffordable?
- 178 2. Is it **P**ractical?
- 179 3. Will it be **E**ffective/Cost-Effective?
- 180 4. Is it **A**cceptable?
- 181 5. Is it **S**afe?
- 182 6. Does it have **E**quity? (APEASE)

183 The intervention function 'coercion' (i.e. create expectation of punishment) was chosen to intervene on
184 the *physical* Opportunity of the sport nutrition professional and *reflective* Motivation of the club. For
185 example, the athlete received sanction if he did not attend organised nutrition sessions, whereas, it
186 negatively impacted the club to not provide the athlete with the resources necessary for optimal

187 development. The intervention functions ‘environmental restructuring’ (i.e. provide a weighing scale)
188 and ‘enablement’ (i.e. provide free high quality food stuffs) were chosen to increase the *physical*
189 Capability and *automatic* Motivation of the athlete, respectively.

190

191 **Step 6: Identify Policy Categories** - Seven policy categories sit on the outer layer of the BCW (Michie et
192 al., 2014). Policies identify how specified intervention functions will be delivered. For example, the
193 intervention function ‘enablement’ was appropriately delivered via ‘regulation’ (i.e. establishing rules to
194 ensure the athlete remembered to report their fasted BM bi-weekly). The intervention functions
195 ‘environmental restructuring’ and ‘coercion’ were delivered via ‘regulation’ and ‘legislation’,
196 respectively.

197

198 **Step 7: Identify Behaviour Change Techniques** – Behaviour change techniques (BCTs) are the ‘active
199 ingredients’ within an intervention, designed to bring about the desired behavioural change (Michie et
200 al., 2014). There are 93 consensually agreed BCTs (Michie et al., 2011), which were systematically
201 chosen in response to identified intervention functions and contextualised via the APEASE criteria.
202 Examples utilised within this nutritional intervention include, ‘goal setting’ (i.e. to consume six meals
203 consistently each day) and ‘self-monitoring of behaviour’ (i.e. self-reported fasted BM assessments).

204

205 **Step 8: Identify Mode of Delivery** - The final stage of the BCW involves identifying how each aspect of
206 the intervention will be implemented. All available options were contextualised and systematically
207 selected via the APEASE criteria. This intervention utilised group and individual face-to-face delivery (i.e.
208 coercion via legislation – contractual agreement between the club and significant others outlining the

209 requirement for the athlete to attend all nutrition sessions) and group and individual cellular contact
210 (i.e. enablement via regulation – the athlete must respond to WhatsApp reminders from the sport
211 nutrition professional when completing his self-reported BM assessment).

212

213 **Outcome of the Intervention**

214 The athlete increased his BM by 6.2 kg across the twelve-week intervention, exceeding the targeted 5 kg
215 gain by 24%. As such, the intervention was deemed successful. BM changes consisted of a 4.8 kg and 1.6
216 kg increase in FFM and fat mass, respectively, representing only a 0.2 % increase in body fat. Such
217 changes evidence the quality of dietary intake (Appendix 1), which included a reduction in average
218 alcohol and free-sugar intakes by 18g and 120g per day, respectively. The athlete reported no symptoms
219 of gastro-intestinal discomfort throughout the assessment period. Nutritional improvements occurred in
220 conjunction with a notable 305 N improvement in the mid-thigh pull, a surrogate measure of absolute
221 strength (McGuigan & Winchester, 2008). Finally, the athlete also reported no symptoms of illness
222 across the intervention period, attending all 61 training sessions. Collectively, these results suggest that
223 the average 24.5 MJ daily energy intake of the athlete, although 0.6 MJ less than targeted, was sufficient
224 to meet energy availability demands (Mountjoy et al., 2014, 2015).

225

226 **Conclusion and Practical Considerations**

227 Delivering successful dietary intervention is integral to the role of sport nutrition professionals. The BCW
228 represents an easy and practical way to design and implement more efficacious dietary intervention
229 within high-performance sport (Atkins & Michie, 2015). Despite this, athletes are individuals and will
230 behave uniquely in response to intra-personal, inter-personal and external factors (Ogden, 2016).

231 Therefore, practitioners are encouraged to perform deliberate practise before real-life application,
232 taking advantage of the considerable resources available to guide more successful implementation.

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Table 1. Anthropometric and Strength Assessment Pre-and Post-Intervention

Athlete Characteristic	Baseline	Post-Intervention	Percent Change (%)
Body mass (kg)	84.6	90.8	7.3
Lean-tissue mass (kg)	64.3	69.0	7.3
Bone mineral content (kg)	3.2	3.3	3.1
Fat mass (kg)	17.1	18.5	8.2
Body Fat Percentage (%)	20.2	20.4	1
ISAK sum of eight skinfolds (mm)	83	90	8.4
Strength Assessment (3RM)	Baseline	Post-Intervention	Percent Change (%)
Bench press (kg)	112.5	120	6.7
Prone row (kg)	86.5	92.5	6.9
Military press (kg)	60	65	8.3
Back squat (kg)	125	135	8.0
Mid-thigh pull (N)	3,242	3,547	9.4

Table 2. Average Daily Dietary Intake Pre-and Post-Intervention

Average Dietary Intake	Baseline	Post-Intervention	Percent Change (%)
Carbohydrate (g)	440	645	46.6
Free sugar (g)	178	58	-67.4
Fat (g)	142	213	50.0
Saturated (g)	42	84	100.0
Protein (g)	142	331	133.1
Alcohol (g)	18	0	-100
Total Energy Intake (MJ)	16.7	24.5	46.7

Table 3. Specification of the Target Behaviours and COM-B Behavioural Analysis

Target Behaviour	<i>Who</i>	<i>What</i>	<i>When</i>	<i>Where</i>	COM-B Behavioural Analysis
1. Increase the knowledge of the athlete, and significant others, about the health, development and performance benefits of consuming a high quality dietary intake of 25.1 MJ (6,000 kcal) each day.	sport and exercise nutritionist	Oral presentation / written information / infographics / other support as required	Start of twelve-week intervention / as required throughout	Club / appropriate social media platforms for athlete (i.e. WhatsApp), and significant others (i.e. google drive, text, email)	<i>Physical Opportunity – Sport and Exercise Nutritionist</i>
2. Increase the knowledge of the athlete, and significant others, about how to achieve a high quality dietary intake of 25.1 MJ (6,000 kcal) each day. This should specify what to eat, in what quantities and at what times.	sport and exercise nutritionist	Oral presentation / written information i.e. diet plan(s) & guide(s) / shopping list(s) / infographics / accessible recipes / other support as required	Start of twelve-week intervention / as required throughout	Club / appropriate social media platforms for athlete (i.e. WhatsApp), and significant others (i.e. google drive, text, email)	<i>Physical Opportunity – Sport and Exercise Nutritionist</i>
3. Provide the athlete with free and discounted high-quality food and batch-tested supplements, as available to first team athletes.	Club	Free batch tested supplements i.e. whey protein, creatine, mass gainer / free meals around training and competition i.e. breakfast, pre-& post-game meals or snacks / snacks available at 'food station' / cost price meat bundles delivered to house / discount on sponsored products i.e. biltong	Start of twelve-week intervention / as required throughout	Club / home (delivered)	<i>Reflective Motivation – Club</i>
4. Regularly assess the BM of the athlete. Progress should be immediately relayed back to him, significant others and the head coach.	Athlete & sport and exercise nutritionist	Bi-weekly fasted weigh-in (self-reported by athlete) / weekly sum of 8 skinfolds (Sport and Exercise Nutritionist)/ feedback results (Sport and Exercise Nutritionist)	Monday & Thursday mornings (weigh-in) / Monday mornings (skinfolds)	Club / appropriate social media platforms for athlete (i.e. WhatsApp), and significant others (i.e. google drive, text, email)	<i>Physical Capability & Automatic Motivation – Athlete</i> <i>Physical Opportunity – Sport and Exercise Nutritionist</i>

5. Provide the athlete with regular, immediate and accessible support via the cellular network.	sport and exercise nutritionist	Information, advice, knowledge / prompts, cues, nudges / feedback, encouragement / other support as required	As required throughout	Club / appropriate social media platforms for athlete (i.e. WhatsApp), and significant others (i.e. google drive, text, email)	<i>Physical Opportunity – Sport and Exercise Nutritionist</i>
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Baseline Dietary Intake.

Baseline – Week Day		
Food or Drink	Portion	Time of Intake
Weetabix	80g (x4)	07:00
Skimmed Milk	270ml	
Tea (skimmed milk and x1 teaspoon sugar)	260ml	
Crisps	45g (x1)	10:15
Club Penguin	35g (x1)	
Apple	152g	
Lucozade	380ml	
Lasagne	290g	13:30
Oven Chips	180g	
Tomato Ketchup	24g	
Coke	330ml (x1 can)	
Tea (skimmed milk and x1 teaspoon sugar)	260ml	15:00
Digestive Chocolate Biscuits	64g (x4)	
Powerade	500ml	During Training
Chicken Breast	100g (x1 small breast)	20:30
Sweet Potato Fries	120g	
Orange Juice	300ml	
Galaxy Chocolate Bar	42g	
Cheerio's	35g	11:30
Skimmed Milk	135ml	
Tea (skimmed milk and x1 teaspoon sugar)	260ml	
Digestive Chocolate Biscuits	80g (x5)	
Daily Dietary Intake		
Carbohydrate (g)	519	
Free sugar (g)	200	
Fat (g)	136	
Saturated (g)	51	
Protein (g)	159	
Alcohol (MJ)	0	
Total Energy Intake (MJ)	16.8	

Baseline – Weekend Day		
Food or Drink	Portion	Time of Intake
Fried Egg	120g (x2)	10:45
Pork Sausage	110 (x2)	
Fried Tomato	50 (x3 slices)	
Hash Brown	80g	
Toast (Brown)	64g	
Butter	10g	
BBQ Sauce	24g	
Tea (skimmed milk and x1 teaspoon sugar)	260ml	
Orange Juice from Concentrate	250ml	14:00
Banana	100g	
Nandos Chicken - Medium	½ Chicken	18:00
Peri Peri Chips	Regular (x2)	
Mayonnaise	24g	
Fanta	285g	
Cider Bottle	1320ml (x4)	21:00
Heineken Bottle	1650ml (x5)	
Daily Dietary Intake		
Carbohydrate (g)	324	
Free sugar (g)	151	
Fat (g)	159	
Saturated (g)	35	
Protein (g)	147	
Alcohol (MJ)	3.8	
Total Energy Intake (MJ)	17	

Week 12 Dietary Intake.

19

Week 12 - Week Day

Food or Drink	Portion	Time of Intake		
Protein Weetabix	100g (x6)	07:15	Mass Gainer*	150g (x3 Scoops)
Full Fat Milk	300ml		Creatine*	5g
Mixed Nuts & Raisins	40g		Full Fat Milk	568ml
Banana	100g		Lamb Chomps	160g
Arla Quark Yogurt	200g		Mash Potato	250g
Fresh Orange Juice	250ml		Runner Beans	65g
Fish Oil Capsule*	2g (x2)		Swede	60g
			Gravy	50g
Tuna Melt with Salad	250g	10:15	Full Fat Milk	300ml
Biltong	40g (x1)		Chocolate Mousse	70g
Large Orange	160g		Strawberries	65g
Club Penguin	35g (x1)			
Crisps	45g (x1)		Fage Greek Yogurt	150g
Oasis Summer Fruits	500ml		Honey	20g
			Oats	40g
Chewing Gum	3g (x1)	11:15	Frozen Berries	60g
			Banana	100g
Roast Beef	150g	13:00	Nutella	30g
Roast Potatoes	190g		Full Fat Milk	200ml
Carrot	85g			
Cauliflower	80g		Daily Dietary Intake	
Gravy	50g		Carbohydrate (g)	674
Full Fat Milk	300ml		Free Sugar (g)	65
			Fat (g)	202
Soreen Malt Loaf	60g	Pre-Training	Saturated (g)	79
			Protein (g)	352
Powerade	500ml	During Training	Alcohol (MJ)	0
			Total Energy Intake (MJ)	24.7

Week 12 - Weekend Day

Food or Drink	Portion	Time of Intake			
Scrambled Egg	180g	09:45	Asparagus	90g	
Heinz Beans	175g		Mixed Vegetables	80g	
Bacon	105g (x3)		Full Fat Milk	300ml	
Mushrooms	80g		White Magnum	90g	20:30
Fried Tomato	50g (x3 slices)		Fage Greek Yogurt	150g	23:00
Toast (White)	60g (x2)		Honey	20g	
Butter	10g		Kiwi	60g	
Full Fat Milk	300ml		Banana	100g	
Fish Oil Capsule*	2g (x2)		Peanut Butter	45g	
BLT	165g	11:30	Full Fat Milk	200ml	
Weetabix On The Go Protein	275ml		Creatine*	5g	
Crisps	45g		Daily Dietary Intake		
Banana	100g		Carbohydrate (g)	466	
Kit Kat	22g (x1)		Free Sugar (g)	54	
Subway Foot Long - Meatball Marina	300g	13:00	Fat (g)	268	
Tropicana Orange Juice	330ml		Saturated (g)	104	
Pear	160g		Protein (g)	264	
Arla Quark Yogurt	200g		Alcohol (MJ)	0	
Seeds	14g		Total Energy Intake (MJ)	22.2	
Mixed Berries	40g				
Oasis	500ml				
Salmon Fillet (x2)	210g	20:00			
Uncle Ben Microwave Rice	100g				