Année universitaire 2021/2022
Sujet examen

UNIVERSITÉ
TOULOUSE III
PAUL SABATIER   Université de Toulouse

FACULTÉ DES SCIENCES DU SPORT
ET DU MOUVEMENT HUMAIN

Vous répondrez aux sujets suivants, en composant sur deux copies différentes.

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Questions de B. Watier (12 points):

Dans le modèle de Samozino (Samozino et al., 2016), les accélérations a(t), vitesses v(t), et positions x(t) d'un sprinter sont modélisées par les fonctions suivantes :

$$a(t) = \frac{v_{max}}{\tau} e^{-\frac{t}{\tau}}$$

$$v(t) = v_{max}\left(1 - e^{-\frac{t}{\tau}}\right)$$

$$x(t) = v_{max}\left(t + \tau.\left(e^{-\frac{t}{\tau}} - 1\right)\right)$$

Ou v_{max} est la vitesse maximale atteinte et τ une constante de temps.

La force de propulsion est classiquement donnée par :

$$F = m.a(t) + F_{aero}$$

Avec, en l'absence de vent :

$$F_{aero} = k.v(t)^2$$

Et

$$k = \frac{1}{2}\rho_0.C_d.A_f$$

Avec:

$$\begin{cases} C_d = 0,9 \\ \rho_0 = 1,292 kg/m^3 \\ A_f = 0,05386 * h^{0,725} * m^{0,425} \end{cases}$$

Ou h est la taille du sprinter et m sa masse.

A l'aide de cellules, on a déterminé un jour sans vent sur un sprinter de 1,80m et de masse 75kg, la constante de temps $\tau = 2s$.

1) Déterminez v_{max} sachant que l'on a enregistré un temps de 5,3s au 40m.

On obtient alors les valeurs de vitesse et d'accélération suivante au cours des 12 premières secondes :

t (s)	0	1	2	3	4	5	6	7	8	9	10	11	12
v (m/s)	0,00	4,57	7,35	9,03	10,05	10,67	11,04	11,27	11,41	11,49	11,54	11,58	11,59
a (m/s^2)	5,81	3,52	2,14	1,30	0,79	0,48	0,29	0,18	0,11	0,06	0,04	0,02	0,01

2) Est-ce que la vitesse maximale obtenue à la question 1 est cohérente avec ces valeurs ? Justifiez.
3) Déterminez et tracez la position en fonction du temps pour les 12 premières secondes.
4) Au bout de combien de temps les 100 premiers mètres seront ils effectués ?
5) Déterminez et tracez la force de propulsion en fonction du temps pour les 12 premières secondes.
6) Déterminez et tracez la puissance développée par l'athlète en fonction de sa vitesse pour les 12 premières secondes.
7) Donnez la puissance maximale. Comparez à la valeur empirique $P_{max} = \frac{v_{max} F_{max}}{4}$. Quelle marge d'erreur commettez vous en utilisant cette dernière relation ?

Questions de J. Duclay (8 points):

1. Comment évolue la force produite par électrostimulation au cours d'une séance d'électrostimulation à intensité constante ? Quels paramètres pourraient influencer cette évolution ?
2. Pourquoi le coût métabolique d'une contraction par électrostimulation est-il augmenté par rapport à une contraction volontaire ?
3. Peut-on parler d'adaptations structurales spécifiques à l'entrainement de force par électrostimulation ? Une réponse argumentée est attendue
4. Quel est le principe d'un programme d'électrostimulation de type " Wide Pulse High Frequency".

Vous répondrez aux sujets suivants, en composant sur deux copies différentes.

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Questions de P. Cantayre (10 points):

1) Après avoir expliqué l'analyse SWOT et la matrice TOWS (5 lignes), donner un exemple de stratégie possible et sa déclinaison opérationnelle (différent de ceux présentés en CM).

2) Présenter les 3 indispensables dans la mise en œuvre d'un plan de développement (5 lignes maxi) ?

Question de L. Carpene (10 points):

Quels tests peuvent être mis en place pour détecter de possible blessure? Présenter différents tests et justifier.

UNIVERSITÉ TOULOUSE III
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FACULTÉ DES SCIENCES DU SPORT
ET DU MOUVEMENT HUMAIN

Session 1 : **Décembre 2021**

Année de formation : **Master 2 EOPS**

Intitulé et code de l'épreuve : **SIESA1EM : « Suivi du sportif de haut niveau et santé »**

Nom du responsable du sujet : **Isabelle HARANT FARRUGIA**

Durée prévisionnelle : 1 heure sur les 2 heures totales de l'épreuve ; Barème : 20 points

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Documents et matériel non autorisés ☒

- **Répondez sur une copie séparée en indiquant le nom du correcteur.**
- **Un point sera enlevé** à la note de la copie à partir de cinq fautes d'orthographe, de grammaire, de syntaxe… ou pour écrits illisibles.
- **N'utilisez pas d'abréviation sans la définir.**
- **Bien reporter le numéro de chaque question sur la copie.**

➢ **Question 1. (5 points)**
La figure ci-dessous présente les résultats des synthèses protéiques totales (A) et de l'oxydation de la Leucine (B) chez des sportifs entraînés en sports de force soumis pendant 13 jours à trois régimes isocaloriques à apport différent en protéines : faible (0,9 g/kg/j), modéré (1,4 g/kg/j), élevé (2,4 g/kg/j).
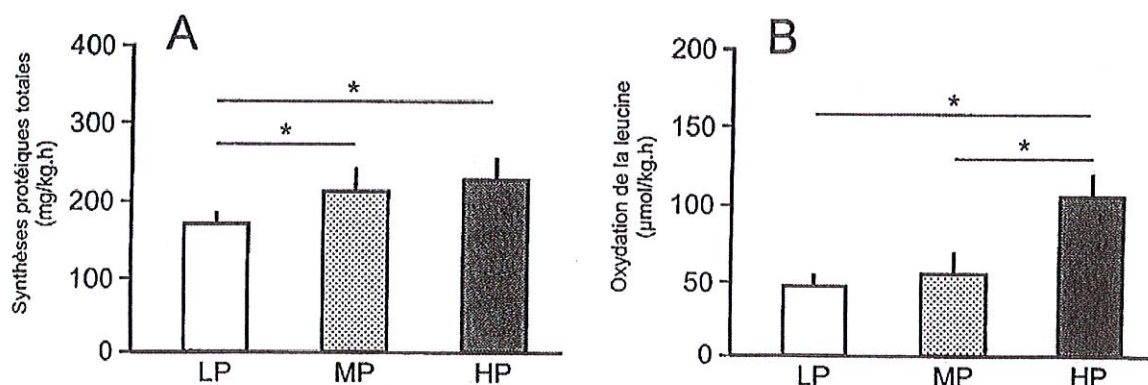Analysez et commentez ces résultats

Figure 10. Evaluation des synthèses protéiques totales de l'organisme (A) et de l'oxydation de la leucine (B) chez des athlètes entraînés dans un sport de force et soumis à un régime à faible apport en protéines (LP, 0,9 g/kg.j), modéré (MP, 1,4 g/kg.j) et élevé (HP, 2,4 g/kg.j). *, différence avec les mesures réalisés pour le faible apport en protéines, $P<0,05$.
(d'après Tarnopolsky et coll., 1992)

> **Question 2.** (6,5 points)

Décrivez et commentez le graphe ci-dessous.
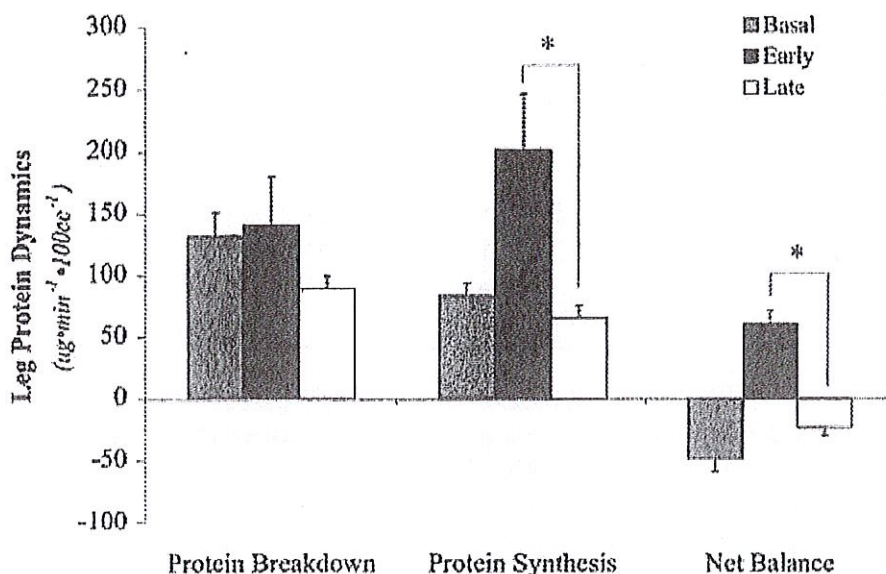
Rates of leg protein dynamics for 10 subjects given an oral nutrient supplement (10 g protéin, 8 g carbohydrate, 3 g lipid) either immediatly after exercise (Early) or 3 h postexercise (Late) (bicycle exercise 60-min at 60 % VO₂max). Data are expressed as means ± SEM. * Significantly different Early vs Late ($p < 0.05$). (Levenhagen DK. et al., 2001)

> **Question 3.** (8,5 points)

Monsieur H., âgé de 30 ans, ingénieur, pratique le triathlon en compétition régionale depuis 5 années. Il s'entraîne 6 fois par semaine pour un volume horaire hebdomadaire de 10 heures.

Son objectif prochain est le triathlon d'Embrun (longue distance).

Il consulte dans le Service de Médecine du Sport du CHU pour évaluer sa possibilité en endurance et optimiser la personnalisation de son entraînement.

A l'interrogatoire, il signale au médecin du sport qu'il a déjà réalisé des tests de terrain sur vélo et en course à pied. Au cours de ces tests, sa fréquence cardiaque maximale observée en vélo était de 168 batt.min⁻¹ et de 174 batt.min⁻¹ en course à pied.

Les données anthropométriques de Mr H sont les suivantes :
- poids : 71,0 kg ; taille : 180,7 cm
- pourcentage de masse grasse estimé par la méthode des plis cutanés : 6 %

Après l'interrogatoire et l'examen clinique, Mr H réalise un test de détermination de sa consommation maximale d'oxygène sur ergocycle au cours duquel sont mesurés les échanges gazeux respiratoires.

En page 3, sont présentées les évolutions de la consommation d'oxygène et du débit ventilatoire au cours du test d'exercice. La fréquence cardiaque maximale soutenue est de 187 batt.min⁻¹.

- **Question 3.1.** Les indices anthropométriques de Mr. H sont-ils compatibles avec son objectif sportif ? Justifiez votre réponse.

- **Question 3.2.** Peut-on considérer le test d'exercice comme maximal ? Sur quels indicateurs basez-vous votre réflexion ?

- **Question 3.3.** Quelle est la valeur du $\dot{V}O_2$max de Mr. H ? Pensez-vous que cette valeur soit compatible avec son objectif sportif ? Justifiez chacune des réponses.
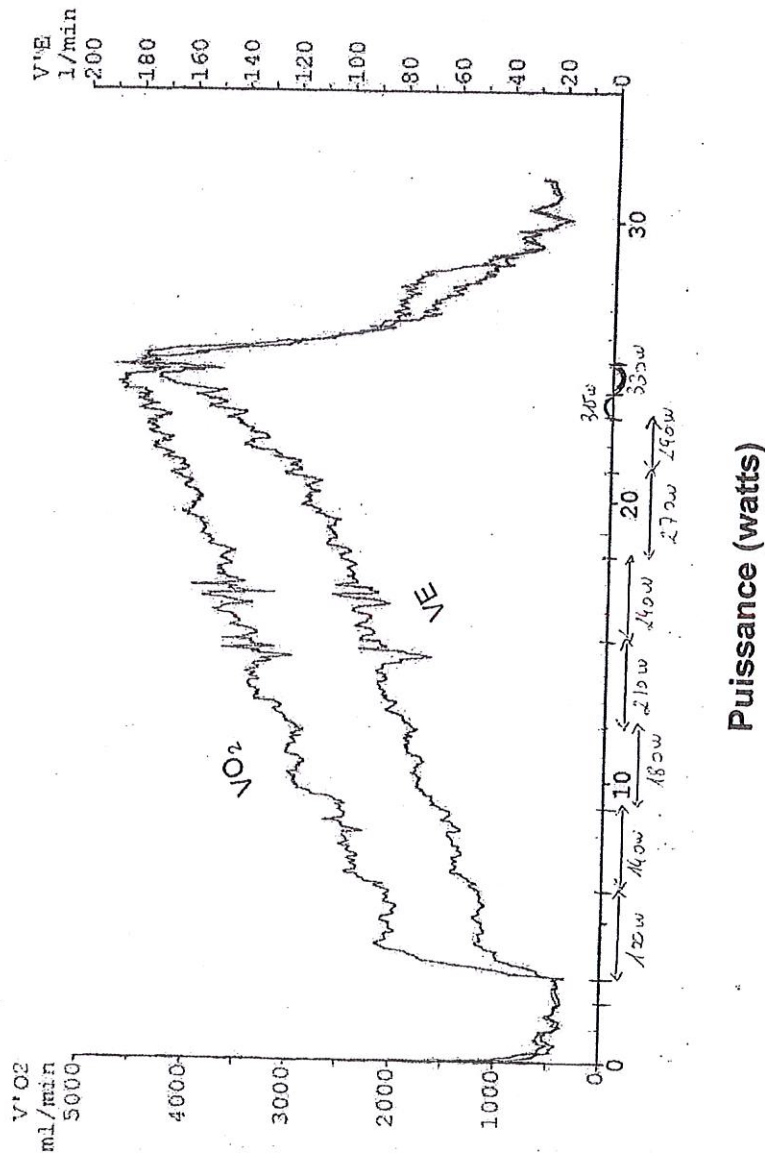
VO_2 : consommation d'oxygène (ml/min)

VE : débit ventilatoire (l/min)

M2 EOPS

CTE, Anglais, décembre 2021

Responsable du sujet : E. Hancock

Durée : 2h

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Read this paper and answer the following questions:

"A Low-Carbohydrate Ketogenic Diet Reduces Body Mass Without Compromising Performance in *Powerlifting* and Olympic Weightlifting Athletes," Greene, David A.; Varley, Benjamin J.; Hartwig, Timothy B.; Chapman, Phillip; Rigney, Michael. Journal of *Strength* and Conditioning Research: December 2018 - Volume 32 - Issue 12 - p 3373-3382

I.VOCABULARY: Provide a synonym in English for these terms from the study. /4

Ex.: an ad libitum diet= you can eat as much as you want (based on satiety)

1)aim to transiently reduce body weight   2) impaired performance

3) concomitant   4)additional factors seem likely

5)confounding variables   6)resting energy expenditure   7)in the fasted state

8)were assessed in a weightlifting facility

II. COMPREHENSION: Answer the following questions in your own words (in English). /5

1.What is already known about this topic?

2. What study design was chosen and was this appropriate given the study's objective?

3. In scientific studies like this one, what is the main difference between the primary and the secondary outcome measures?

4. What are the primary and secondary outcome measures in this study?

5. What are the findings of this study?

III. SHORT-ANSWER QUESTION (minimum 100 words) /11

Content (clarity, connection theory-practice) /4   Form (vocabulary, grammar, link words) /7

OPTIMIZING PERFORMANCE: As a conditioner, you have your role to play in enhancing your athletes' performance. **Who are the other professionals that have a key role to play? How are their roles different yet complementary? Provide at least 1 example from your own training experience (as an athlete or a strength and conditioning coach).**

A Low-Carbohydrate Ketogenic Diet Reduces Body Mass Without Compromising Performance in Powerlifting and Olympic Weightlifting Athletes

David A. Greene, Benjamin J. Varley, Timothy B. Hartwig, Phillip Chapman, and Michael Rigney

School of Exercise Science, Australian Catholic University, Strathfield, New South Wales, Australia

Introduction

Weight class sports require athletes to maximize performance while carefully controlling body weight to compete in a specific weight class with an optimum power-to-weight ratio. Competing at the upper-end of a weight class is advantageous, and most athletes therefore aim to transiently reduce body weight to make weight for competition. Targeted weight reduction can be accomplished by energy deficit (34), but rapid weight loss strategies are also frequently used (15). Reducing weight is challenging, and weight-making strategies are not always effective for all athletes. Weight-making strategies can also result in impaired performance (40), compromised lean body mass (LBM (12)), and deleterious health outcomes (10,15). Strategies that allow athletes to effectively reduce body weight without compromising health or performance are therefore of importance.

Recent studies in athletic and nonathletic populations have shown weight loss without energy restriction using diets that reduce carbohydrate and increase fat intake (1,20,26,31,36,41). There is also some evidence that weight loss arises from reductions in fat mass with a concomitant preservation of lean mass (3,26,38,41). Low-carbohydrate, high-fat diets might therefore be a useful weight-making strategy for athletes competing in weight class sports. However, before such dietary strategies could be recommended, they would need to also demonstrate that they do not compromise performance. The impact of low-carbohydrate, high-fat diets on athletic performance has been explored in a number of studies (20,26,41). Most studies have investigated aerobic performances in endurance-based sports. However, a few recent studies have examined the effects of
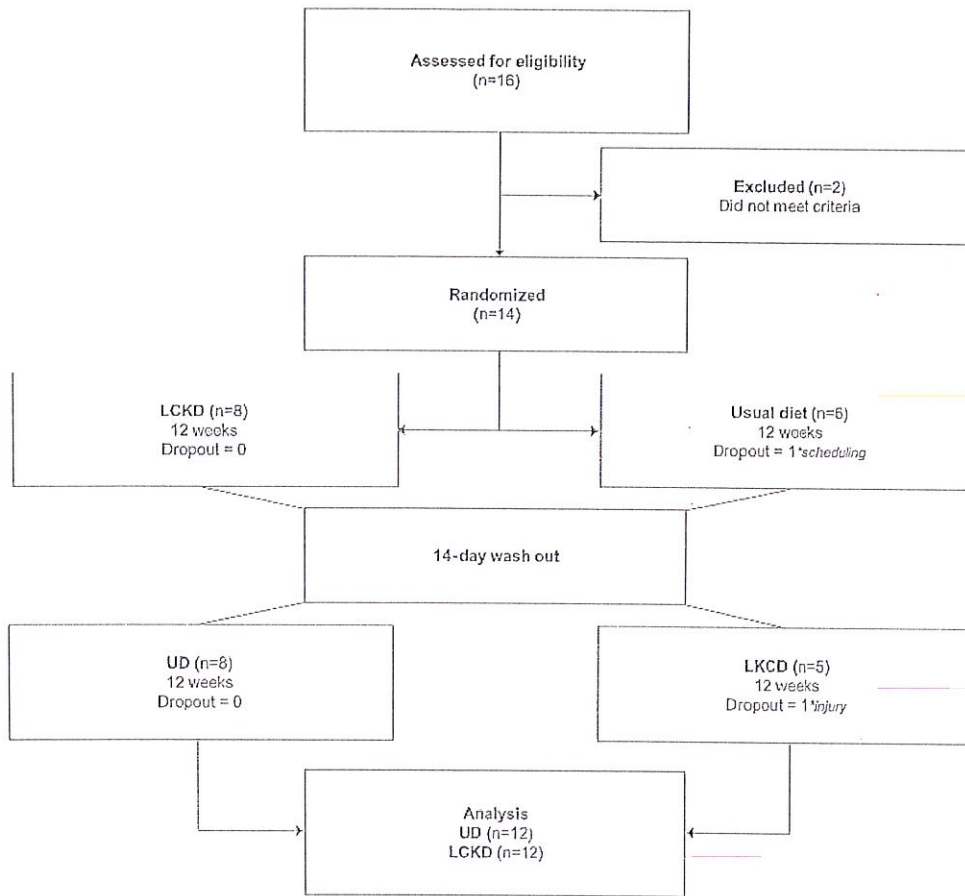
Figure 1. CONSORT flow diagram. LCKD = low-carbohydrate ketogenic diet; UD = usual diet.

low-carbohydrate, high-fat diets on strength and power. Sawyer et al. (31) showed maintenance in strength and power after short-term (7 days) carbohydrate restriction in resistance training men and women. In resistance training men, increases in strength and power were comparable between an 8-week low-carbohydrate, ketogenic diet (LCKD) group and a group consuming a high-carbohydrate, western diet (41). Paoli et al. (26) reported a preservation of strength in elite gymnasts after a 4-week ketogenic diet. Collectively, these studies suggest that a low-carbohydrate, high-fat diet or LCKD might be useful for reducing body weight without compromising strength and power. However, with the exception of the study by Paoli et al. (26), previous studies have used recreational athletes. Therefore, the efficacy of LCKD for performance and body composition among athletes competing in weight class sports that require maximal strength and power remains underexplored.

Little is known about the mechanisms underlying weight reduction and body composition changes during LCKD. Altering macronutrient intake could affect body weight through changes in fluid and fuel storage. Transitioning to an LCKD reduces fluid retention (25,29) and stored glycogen (16) that would both contribute to reductions in weight. However, the reductions in weight associated with these initial adaptations to LCKD are modest, and additional factors seem likely. An LCKD alter the efficiency of metabolic pathways (11), promote the oxidation of fatty acids (37,39), and could alter resting and exercising energy expenditure (8), but additional studies are needed to better understand the contribution of these mechanisms to weight loss during LCKD.

The role of altered skeletal muscle metabolism during LCKD and the impact on training, adaptation, and performance are also unclear. Currently, sports dietary guidelines for strength and power performance emphasize a high-carbohydrate intake. This is related to concerns of the impact of glycogen depletion

TABLE 1. Composition of diets.*†

	UD		LCKD		
	Mean	±SD	Mean	±SD	p
Carbohydrate (g·d⁻¹)	222.8	54.9	39.3	10.8	0.001
Male	247.7	51.7	41.6	11.6	
Female	188.0	41.1	36.0	9.7	
Fat (g·d⁻¹)	78.7	23.7	163.8	43.7	0.001
Male	89.7	21.7	189.3	33.6	
Female	63.4	18.1	128.1	28.8	
Protein (g·d⁻¹)	119.2	50.3	121.3	36.6	0.844
Male	132.8	55.5	134.7	36.2	
Female	100.3	39.5	102.6	31.0	
Carbohydrate (%)	44.8	4.8	8.1	2.0	0.001
Male	44.7	2.8	7.5	2.1	
Female	45.1	7.1	8.9	1.7	
Fat (%)	33.2	6.0	69.1	5.6	0.001
Male	33.7	6.2	70.1	6.6	
Female	32.4	6.3	67.6	4.1	
Protein (%)	22.0	6.0	22.9	4.6	0.492
Male	21.7	6.5	22.4	5.7	
Female	22.5	5.8	23.5	2.9	
Energy intake (kJ·d⁻¹)	8,609	2,103	8,671	2005	0.895
Male	9,653.2	1885.4	9,868.1	1,322.9	
Female	7,147.5	1,500.9	6,995.5	1,554.5	

*UD = usual diet; LCKD = low-carbohydrate ketogenic diet.
†n = 12; female = 5 and male = 7.

on fatigue and adaptation (4,28), but the role of exogenous carbohydrate in this context has recently been challenged (9,27). There is, for example, no evidence that carbohydrates are required for signaling of mammalian target of rapamycin complex 1 during muscle protein synthesis (6). Dietary carbohydrate also does not augment muscle protein synthesis when dietary protein is adequate (27). Furthermore, an LCKD-induced metabolic shift toward fat oxidation (and glycogen sparing) could have favorable effects on ATP resynthesis during resistance exercise training (39).

There is evidence that an LCKD might offer specific advantages for weight reduction without the negative impact on strength and power previously hypothesized to accompany carbohydrate restriction. To the best of our knowledge, no studies have explored the efficacy of an LCKD as a weight-making strategy for competitive weight class athletes by examining the impact on body weight, body composition, and performance. Therefore, the purpose of this study was to determine whether an LCKD could be used as an efficacious weight reduction strategy for athletes competing in the weight class sports of powerlifting and Olympic weightlifting. A secondary purpose was to examine metabolic changes in fuel utilization and energy expenditure during LCKD. We hypothesized that consuming an ad libitum LCKD would result in practically meaningful reductions in body mass with lifting performances comparable with usual diet (UD).

METHODS

Experimental Approach to the Problem

To test the hypothesis, a randomized, crossover design was selected. In addition to reducing confounding variables at baseline, a crossover design provided sufficient power while recruiting competitive athletes for a long-term dietary intervention. Subjects consumed an ad libitum UD (>250 g daily intake of carbohydrates) and an ad libitum LCKD (≤50 g or ≤10% daily intake of carbohydrates) in random order, each for 3 months in a crossover design with a 2-week washout. Lifting performance, body composition, resting metabolic rate (RMR), blood glucose, and blood electrolytes were measured at baseline, 3 months, and 6 months at the university's laboratories. Subjects used online tools (MyFitnessPal, Baltimore, MD, USA and Qualtrics, Provo, Utah, USA) to log self-reported dietary intake, self-monitored blood glucose and blood ketones, and weekly training measures. Self-reported measures were logged 3 times per week on 2 weekdays and a weekend day in weeks 1, 4, 7, 10, and 12 in each study phase.

Subjects

Fourteen intermediate to elite level powerlifters and Olympic weight lifters (mean ± SD, age 35 ± 11 years, range 24-53 years, mass 78 ± 12 kg, body fat 17.5 ± 4.6%, n = 5 female) who competed at a local to national level were recruited to

TABLE 2. Training characteristics.*†

	UD		LCKD		
	Mean	±SD	Mean	±SD	p
Training sessions·wk^{-1}	4.2	1.5	4.3	1.2	0.696
Training mins·wk^{-1}	324	116	332	98	0.630
Training load	2003	705	2089	735	0.587

*UD = usual diet; LCKD = low-carbohydrate ketogenic diet.
†Training load = training minutes × rate of perceived exertion (arbitrary units).

participate in this study (Figure 1: CONSORT flow diagram). Two subjects withdrew from the study; one due to illness and the other due to scheduling conflicts. Subjects had an average lifting experience of 6.2 ± 5.8 years and were free of limiting musculoskeletal injuries at the time of recruitment. Inclusion criteria included age between 18 and 55 years and a minimum 6 months competitive lifting experience. After being informed of the risks and benefits of the study, subjects provided written consent. The study procedures were approved by the Australian Catholic University Institutional Review Board (2016-76H). The trial was registered (ACTRN12618000035224). All subjects completed and submitted signed, informed consent prior to commencement.

Procedures

All subjects attended the university's laboratories to undertake testing at baseline, 3 months, and 6 months. Subjects arrived in the morning in a fasted state and were instructed to not consume caffeine or alcohol, or engage in intense training or exercise in the 24 hours before testing. Body composition, resting energy expenditure, and blood measures were conducted in the fasted state. After completing

these tests, subjects were allowed to eat as part of their preparations for performance testing.

Diet. After baseline testing, subjects were randomly allocated to a diet phase. Diets were prescriptive with regards to carbohydrate intake but were ad libitum for total calories. During the LCKD phase, subjects were prescribed target macronutrient levels (70% fat, 20% protein, and ≤50 g or ≤10% carbohydrates) and were provided with nutritional counseling and resources to assist in adhering to the LCKD. Resources included print- and electronic-suggested daily meal plans, meal recipes, and lists of foods "encouraged to eat," "eat in moderation," and "foods to avoid." The food lists encouraged a focus on eating unprocessed food, consisting of cruciferous and green leafy vegetables, raw nuts and seeds, eggs, fish, animal meats, dairy products, and plant oils and fats from avocados, coconuts, and olives (23). Suggested meal plans and meal recipes were formulated to meet subject's micronutrient requirements (43) with special attention to sodium intake because sodium losses have been shown to occur during LCKD (29). Subjects and researchers used an LCKD community Facebook group during the study period to facilitate communication and sharing of LCKD meal recipes. No meals were provided to subjects. Some subjects in the LCKD phases initially expressed concern about the impact of high-saturated fat diet options on cardiovascular health and body composition. In these instances, subjects were given copies of recent articles demonstrating the lack of evidence for "unhealthy" effects of saturated fats (19,23). During the UD phase, subjects were instructed to consume their UD. To mitigate the carry-over effect of being in the

TABLE 3. Primary and secondary study outcomes.*†

	Baseline	UD	LCKD
Body mass (kg)	77.9 (70.2–85.8)	79.4 (70.6–88.2)	76.0 (68.9–83.2)
Fat mass (kg)	13.7 (11.2–16.2)	14.7 (12.1–17.4)	13.7 (11.2–16.2)
Lean mass (kg)	61.1 (54.1–68.1)	61.5 (54.0–69.1)	59.3 (52.8–65.9)
1RM strength (kg)	132 (110–154)	137 (115–160)	135 (111–160)
RMR (kJ·d^{-1})	7,322 (5,983–8,665)	7,586 (6,485–8,673)	7,540 (6,360–8,715)
Measured RQ	0.79 (0.75–0.83)	0.77 (0.75–0.80)	0.76 (0.71–0.80)
Glucose (mmol·L^{-1})	4.9 (4.6–5.2)	5.1 (4.8–5.4)	4.9 (4.6–5.3)
Potassium (mmol·L^{-1})	4.3 (4.1–4.5)	4.4 (4.2–4.6)	4.7 (4.3–5.1)
Sodium (mmol·L^{-1})	145 (143.7–146.3)	143.9 (142.6–145.2)	145.1 (144.0–146.2)

*UD = usual diet; LCKD = low-carbohydrate ketogenic diet; 1RM = 1 repetition maximum; RMR = resting metabolic rate; RQ = respiratory quotient; CI = confidence interval.
†Values are presented as mean (95% CI) for 12 participants.

LCKD phase, subjects crossing over to UD were instructed to ensure they consumed >250 g daily intake of carbohydrates. This amount of carbohydrate was a conservative estimate based on the usual carbohydrate intake of subjects during the UD phase.

Total daily energy intake and macronutrient and micronutrient composition were self-reported through the online smartphone application, MyFitnessPal. Researchers administrated subject's MyFitnessPal user accounts and therefore had the ability to assess and modify the subject's macronutrient and micronutrient intake throughout the intervention. MyFitnessPal has previously been used in clinical trials to track dietary intake (17). Subjects used digital kitchen scales to measure food portions for total energy intake estimates. Subjects in this study were experienced at monitoring energy intake and macronutrient composition because they were accustomed to doing this as part of their usual practices in their respective weight class sports.

Training. Being competitive athletes, subjects had varying individual training and competition schedules during the study period. Subjects were instructed to maintain their normal training during both dietary phases of the study and continued to compete according to their normal competition schedule. Consequently, subjects were in various phases of their training cycle throughout the study. Because standardizing the competition and training schedule was not possible or desirable, we ensured that athletes' competitions did not coincide with the baseline, 3-month, and 6-month research testing. This was accomplished by altering either the research start date or negotiating changes to individual athletes competition schedules. Therefore, although training cycles varied during the study period, no athletes engaged in any other form of weight-reducing strategy within 2 weeks of research testing. Subjects recorded the quality and quantity of training undertaken in both study phases by reporting training session frequency, duration, and intensity using a 10-point scale.

Lifting Performance. One repetition maximum (1RM) was used as the primary performance variable. After a self-selected warm-up, subjects performed either one or all of their competition lifts: snatch and clean and jerk (Olympic weightlifting), squat, bench press, and deadlift (powerlifting). Subjects self-selected the lifts for performance testing. This approach was used to minimize the learning effect that would have occurred if subjects were required to perform unfamiliar lifts. We believe this is the optimal method for assessing performance among well-trained athletes. Lifting performances were assessed in a weightlifting facility using international competition standard bars and plates (Eleiko, Halmstad, Sweden) under the supervision of a researcher qualified to officiate powerlifting and Olympic weightlifting competitions. Performance testing mimicked a competition environment with calls to time to completion. Highest lifts were used for analysis. Athletes and researchers relied on established personal best lifting performances to gauge the reproducibility of lifting performances during research testing. All subjects knew their personal best lifting performances that could be verified from competition records.

Body Composition. Body mass was measured using electronic scales (SECA 813; Hamburg, Germany, ± 0.1 kg). Whole-body composition and estimates of fat and lean mass were measured using dual-energy X-ray absorptiometry (DXA; Medilink Medix DR, 2D-Fan beam, Montpellier, France). Post-test analysis was performed using manufacturer software (Medilink-Eazix Software). The coefficient of variation (CV%) in our laboratory was obtained after the scanning of 9 healthy university students twice, following repositioning. Whole-body CV (%) was 1.3 for lean mass and 1.5 for fat mass.

Resting Energy Expenditure and Fuel Utilization. Resting metabolic rate was estimated by indirect calorimetry using breath-by-breath gas analysis with a ventilated hood canopy (QUARK CPET; COSMED, Rome, Italy). After 30 minutes

TABLE 4. Post hoc pairwise comparisons with Bonferroni adjustment for outcomes with main effects.*†

	Adjusted within-subject factors	Mean difference	SE	95% CI	p	Partial π^2
Mass (kg)	Baseline − UD	1.56	0.95	−1.16 to 4.28	0.392	0.35
	Baseline − LCKD	−1.7	0.93	−4.37 to 0.98	0.298	
	LCKD − UD	−3.26	1.07	−6.34 to −0.18	0.038*	
Lean mass (kg)	Baseline − UD	0.52	0.48	−0.87 to 1.91	0.923	0.45
	Baseline − LCKD	−1.74	0.62	−3.51 to 0.02	0.54	
	LCKD − UD	−2.26	0.64	−4.10 to −0.42	0.016*	

*CI = confidence interval; UD = usual diet; LCKD = low-carbohydrate ketogenic diet.
†Within-subject factors adjusted for the effect of diet sequence.
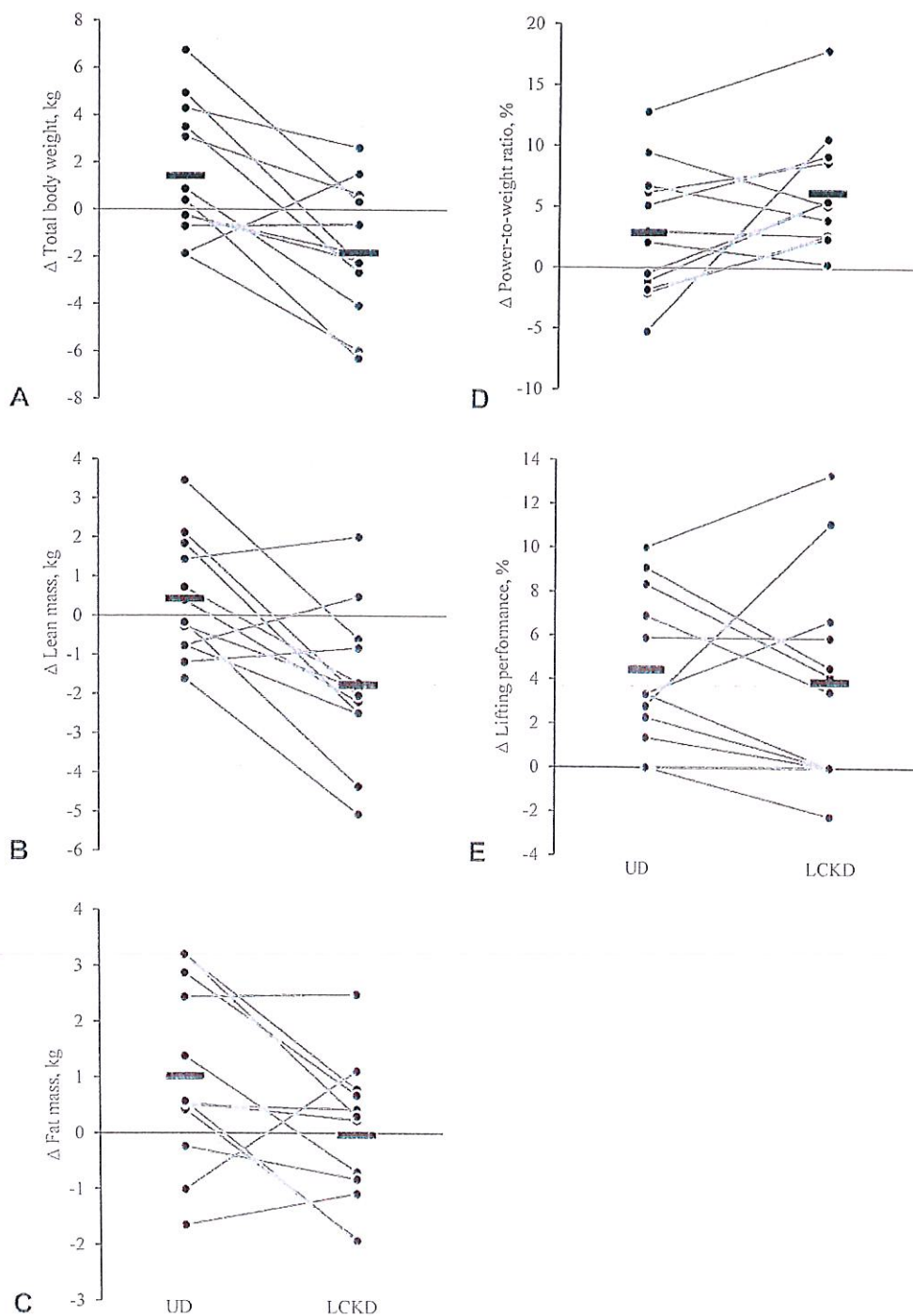
Figure 2. Change in (A) total body mass in kg, (B) lean mass in kg, (C) fat mass in kg, (D) power-to-mass ratio in %, and (E) lifting performance in % during the 2 dietary phases. Changes are relative to baseline measurements. Solid bars indicate mean group change. Connected dots indicate individual changes. Total body mass ($p = 0.038$) and lean mass ($p = 0.016$) were significantly different in the 2 diets. Power-to-mass ratio = lifting performance (kg)/body mass (kg); UD = usual diet; LCKD = low-carbohydrate ketogenic diet.

of rest in a supine position, expired gases were measured in awake subjects for 20 minutes. Room temperature was thermoneutral, between 22 and 25° C, and lights were dimmed. The first 5 minutes of data were discarded, and a CV of <10% for oxygen ($\dot{V}O_2$) and carbon dioxide ($\dot{V}CO_2$) was set as the criteria for a test to be accepted as valid, as per standard practice for RMR measurement (5). $\dot{V}O_2$ and $\dot{V}CO_2$ were used to calculate respiratory quotient (RQ) to determine resting fuel utilization.

Blood Sampling and Analysis. Fasting blood glucose and electrolytes (sodium and potassium) were measured in the laboratory at baseline, 3 months, and 6 months. A small capillary blood sample (95 μl) was obtain using dermal puncture and analyzed using a hand-held blood analyzer (I-STAT Chem 8 + cartridge and I-STAT1-300; Abbott Australasia, Macquarie Park, Australia). Sodium and potassium were monitored because electrolyte losses can accompany fluid losses during the transition to an LCKD, which can result in performance decrements (29). To assist in verifying dietary compliance, subjects in the LCKD phase measured their own blood ketones (β-Hydroxybutyrate) and glucose using a portable analyzer (Freestyle Optimum Neo; Abbott Diabetes Care, Maidenhead, United Kingdom). At baseline, subjects were taught how to obtain a finger prick blood sample and use the analyzer. Subjects were then provided with a personal portable analyzer with which to perform these measures on waking and in a fasted state.

Statistical Analyses

Effect sizes from pilot data collected in our laboratory were used in an a priori power analysis for repeated-measures analysis of variance (ANOVA). The trial was designed to provide 80% power to detect meaningful changes in body weight between dietary phases. All data were checked for normal distribution and outliers at each time point using Shapiro-Wilk tests ($p \geq 0.05$) and boxplots, respectively. Descriptive continuous data are presented as mean ± *SD* with paired-sample *t*-tests used to explore differences in independent variables between dietary phases. A 1-way repeated-measures ANOVA was used to test the overall hypothesis that the means of primary outcome variables: (a) body mass, (b) fat mass, (c) lean mass, and (d) 1RM strength performance, and secondary outcomes: (a) RMR and (b) RQ, were equal between baseline, UD, and LCKD. A between-subject factor of diet order (baseline, UD, and LCKD; baseline, LCKD, and UD) was included to adjust for the effect of diet sequence on within-subject factors. The assumption of sphericity was assessed by Mauchly's test of sphericity. Whenever the hypothesis was rejected and a significant main effect identified, we performed a post hoc pairwise comparison with Bonferroni adjustment. A *p* value <0.05 was considered statistically significant, and partial-eta squared (π^2) was used to report effect size with 0.01 considered small, 0.06 medium, and 0.14 large effects

(4). Two subjects were excluded from RMR analysis because their tests exceeded the maximum CV for gas variables. All statistical analyses were performed using IBM SPSS Statistics (V.24.0 for Windows).

RESULTS

There were significant differences in carbohydrate ($p = 0.001$) and fat ($p = 0.001$) intake during LCKD compared to UD with no differences in total energy intake or protein intake (Table 1). Fasting blood ketones (β-hydroxybutyrate) were elevated during LCKD (0.4 ± 0.2 mmol·L^{-1}; range 0.2–1.7). There were no differences in training variables during LCKD and UD (Table 2).

Primary and secondary outcome variables are shown in Table 3. Table 4 shows the mean differences for outcomes with main effects. Within-subject factors in this table have been adjusted for the effect of diet sequence.

Diet had a significant main effect on body mass $F(2, 20) = 5.449, p = 0.013$, partial $\pi^2 = 0.35$ (Table 3). Post hoc analysis revealed that body mass was significantly lower at the end of the 3-month LCKD phase compared with the end of the 3-month UD phase with a mean difference adjusted for the effect of diet sequence of -3.26 ± 1.07 kg, (95% confidence interval [CI], -6.34 to -0.18; $p = 0.038$). Similarly, diet had a significant main effect on lean mass $F(2, 20) = 8.217, p = 0.002$, partial $\pi^2 = 0.45$ over time. Lean mass was significantly lower at the end of the 3-month LCKD phase compared with the end of the 3-month UD phase with a mean difference adjusted for the effect of diet sequence of -2.26 ± 0.64 kg, (95% CI, -4.10 to -0.42; $p = 0.016$). There were no other main effects in primary outcome variables (fat mass and 1RM strength) or secondary outcome variables (RMR and RQ).

Figure 2 presents individual and group mean changes in body composition and performance variables during the LCKD and UD phases compared with measures at baseline.

DISCUSSION

To the best of our knowledge, this is the first study to explore the effect of an LCKD on body mass, body composition, and performance in athletes competing in weight class strength and power sports. Although many strategies are available for athletes wanting to reduce weight, weight-making strategies are not without risks and are not universally effective for all athletes. Powerlifting and Olympic weightlifting athletes in this study decreased body mass and achieved lifting performances that were comparable with their UD when consuming an ad libitum LCKD.

The LCKD resulted in meaningful reductions in body mass compared with both baseline and the end of the UD phase. The physiological basis for this mass loss is not entirely clear. Stored glycogen and the accompanying storage of water contribute up to 2 kg of weight loss during either energy or carbohydrate restriction (16). After accounting for weight loss likely to be associated with glycogen

losses, the mass loss experienced by most subjects in this study was greater than expected based on subjects' energy intake and energy expenditure. Greater than expected mass loss during ad libitum LCKD has previously been reported. For a recent review, see Noakes et al. (23). A reduced energy intake as a result of a greater satiating effect of LCKD has previously been proposed as a mechanism contributing to weight loss during LCKD (13). However, in this study, subjects' reported energy intakes were similar during the 2 dietary phases. There is growing interest in the metabolic effects of LCKD that could contribute to greater than expected weight loss. Several mechanisms that seem to facilitate weight loss may contribute to the efficacy of LCKD for weight loss (11). The thermogenic effect of digesting greater amounts of dietary protein could account for the apparent greater than expected weight loss during LCKD (14). However, protein intakes in the current study were similar during the 2 dietary phases. The role of changes in RMR during LCKD have also been explored as possibly contributing to weight loss (8,11). In our study, RMR was not different during the 2 dietary phases, but changes to RMR are expected to accompany the weight loss observed during the LCKD phase. Weight loss predictably reduces RMR (7,22). This adaptive reduction in RMR is typically reported to occur among overweight or obese subjects when they lose weight; however, this effect has also been demonstrated in athletes losing similar amounts of weight to subjects in this study (21). Although our study may be underpowered to detect small intervention differences in RMR, the potential for LCKD to preserve RMR during weight loss is intriguing and is supported by emerging theories of weight loss and energy balance. In a recent crossover study of overweight and obese patients, a 10–15% reduction in total body weight resulted in decreases in RMR favoring weight regain that were greatest with the low-fat diet phase and least with the very low-carbohydrate diet phase (8).

In the current study, there was a significant decrease in LBM after LCKD relative to UD. Lean body mass losses are an undesirable consequence of weight reduction because of the potential negative effects on performance. Lean body mass losses can occur during energy restriction (10). During LCKD, a greater utilization of amino acids has been proposed to contribute to LBM losses (35). Despite a shift toward fat utilization during carbohydrate restriction, some obligatory requirement for glucose remains. To fulfill this need, gluconeogenic pathways use amino acids to produce glucose and might therefore contribute to protein catabolism (24). However, a number of studies have demonstrated a preservation of LBM during low-carbohydrate diets (3,26,38,41). Furthermore, the measured LBM losses in this study were not accompanied by decrements in lifting performances. Recent studies have shown that DXA may overestimate losses in LBM during carbohydrate restriction and particularly in athletic populations (2,35). Dual-energy X-ray absorptiometry measurement of LBM relies on esti-mates of the distribution of water between intracellular and extracellular compartments (32), which are perturbed during carbohydrate restriction. This has limited our interpretation of the LBM losses observed in this study. A 4-compartment model of body composition such as that used by Wilson et al. (42) could account for changes in total body water and would be a superior approach for assessing the impact of LCKD on body composition. Additional studies are needed to determine the effect of LCKD on LBM in resistance-trained subjects.

Our study found that neither training quality (the ability of athletes to maintain their usual training load) nor lifting performances were adversely affected during a relatively long exposure to an LCKD. This is supported by recent studies that have shown a preservation of strength in resistance training individuals consuming low-carbohydrate diets (26,31,41). Sports dietary approaches for short-duration, resistance exercise have traditionally advised a high-carbohydrate intake. This is likely based on evidence supporting the importance of glycogen as both a fuel for exercise and regulator of skeletal muscle adaptation responses to training (4,28). Thus, dietary strategies that involve carbohydrate restriction have been believed to compromise strength and power performances and longer-term adaptation as a result of diet-induced glycogen depletion (18). Yet, deleterious effects of restricted exogenous carbohydrate have not been demonstrated in resistance exercise (9). Creer et al. (6) studied human muscle cellular growth pathways during a low-carbohydrate diet and found no effect of either low exogenous carbohydrate or low muscle glycogen on signaling of mammalian target of rapamycin complex 1, a crucial step in muscle protein synthesis. Moreover, dietary carbohydrate does not seem to augment muscle protein synthesis when dietary protein is adequate (27). It is also unclear whether glycogen depletion during LCKD persists beyond the initial 4–6 weeks of carbohydrate restriction. Volek et al. (37) recently showed that muscle glycogen was not different in long-term adapted LCKD endurance athletes compared with matched controls consuming a high-carbohydrate diet. Besides exogenous carbohydrate intake, glycogen storage is influenced by provision of gluconeogenic substrates, insulinemic amino acids, glucose uptake into muscle, and insulin sensitivity (4). Although muscle glycogen was not assessed in this study, it is clear that exogenous carbohydrates are not obligatory for glycogen synthesis, and glycogen depletion may not be detrimental to muscle protein synthesis and therefore long-term muscle adaptations.

Low-carbohydrate diets result in a metabolic shift in fuel availability and utilization that include increases in fat oxidation (37,39) and the production of ketones as an alternate fuel source when glucose is low (30,37). These adaptations also do not seem to be detrimental for lifting performance. Waldman et al. (39) recently hypothesized that an increased fat utilization could have favorable effects on ATP resynthesis during resistance exercise by increasing aceyl-CoA dependency on free fatty acids and sparing glycogen. Several studies have explored the role of ketones as

a fuel during endurance exercise (30,37), but the role of ketones as a fuel during resistance exercise is unknown. In this study, there was some evidence of a shift in fuel utilization during LCKD, but the findings were not clear. There was a trend toward greater fat oxidation at rest during LCKD, but differences were not significant. Fasting blood ketones (β-hydroxybutyrate) during LCKD were elevated (mean = 0.4 mmol·L^{-1}; range 0.2–1.7) to levels comparable with previous studies of very low dietary carbohydrate diets (39,43), but in some individual subjects, ketone levels did not rise beyond levels expected during normal carbohydrate availability. Therefore, the role of altered fuel utilization in this study is unclear.

This study provides an important first step in informing evidence-based dietary approaches for weight class lifting athletes. Implementing dietary interventions in a real-world setting presents a number of challenges. To overcome some of these challenges, subjects in this study were prescribed ad libitum diets in both dietary phases that differed only in the relative proportions of macronutrients and were specifically instructed to not engage in energy restriction. Underreporting energy intake, a major challenge in energy restriction (33), was therefore largely eliminated and thus overcame some of the limitations of self-reporting of dietary intake. Similarly, training approaches were not controlled in the current study. Standardized training programs are likely to accentuate a training effect (41). In the current study, experienced lifters followed individualized training programs and were assessed for performance changes using their usual lifts nullifying learning effects and reporting realistic and applicable performance outcomes. However, a number of limitations are needed to be recognized. To promote adherence and minimize the burden on subjects, laboratory testing was conducted at only 3 time points. Although diet order effects could be statistically controlled, additional data collection at the start of each new phase of the study could have strengthened comparisons by establishing new baselines before diet crossover. Furthermore, a 2-week washout period may have been insufficient to eliminate carry-over effects of the previous dietary phase. However, random allocation in the balanced crossover design somewhat diminished the influence of the short washout period. In this study, there were insufficient subjects to explore intervention sex differences in our mixed sex cohort. The ad libitum dietary design also resulted in 1 subject having a different energy intake during the 2 dietary phases. This subject's long-term UD involved a substantively restrictive caloric intake. After being instructed to switch to a 3-month ad libitum LCKD, this subject's total caloric intake increased significantly. Nevertheless, this effect would act as a disadvantage for weight loss during LCKD.

PRACTICAL APPLICATIONS

Weight class sports often require athletes to transiently reduce body weight to make weight for competition. Energy restriction and rapid weight loss strategies used by athletes are not universally effective for reducing weight and can be associated with a number of negative side effects. In this study, a 12-week ad libitum LCKD resulted in practically meaningful reductions in body weight without compromising training or performance and therefore seems safe and suitable to resistance trained athletes who desire lower body mass. We have thus demonstrated an alternate weight-making strategy for weight class athletes involved in power-lifting and Olympic weightlifting. An LCKD might also be applicable to other popular weight class sports including combat sports, but this needs to be explored in future studies. Coaches and athletes should consider using an LCKD to achieve targeted weight reduction goals in favor of either energy restriction or rapid weight loss strategies.

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Année universitaire 2021/2022

Sujet examen

Session : 1ère session

Année de formation : Master 2 EOPS

Intitulé et code de l'épreuve : UE 3P3 – Apport des outils de quantification pour l'entraînement et la préparation physique – SIESA1HM

Nom du responsable du sujet : Serge VAUCELLE

Durée de l'épreuve : 2 heures

Documents et matériels non autorisés ☒

Vous répondrez sur trois copies distinctes. Merci.

Sujet A : Anne ILLE (5 points)

Définissez les fixations visuelles et expliquez leur rôle dans la prise d'information visuelle en sport. (2 pts)

Quelles sont les principales limites de l'oculométrie pour l'étude du regard dans des situations sportives dynamiques (c'est-à-dire lorsque les éléments regardés sont en mouvement et/ou le sportif dont on étudie le regard est en mouvement) ? Expliquez. (2 pts)

Qu'est-ce que le Quiet Eye ? Quelle est sa relation avec la performance ? (1 pt)

Sujet A : Robin BAURES (5 points)

En baseball, un score de performance est le batting average (BA), qui est le nombre de balles frappées divisé par le nombre de fois où le batteur est en position de frappe. Par exemple, un score de .200 signifie que le batteur réussi à frapper 20% des coups. Sur une saison entière, un joueur ayant un score de .300 est considéré comme excellent, un score de .400 est considéré comme inatteignable.

Pour étudier les facteurs cognitifs de la performance (de la simple quantification ou pour intervenir dessus, par exemple réaliser un entrainement particulier sur ces facteurs cognitifs), il est recommandé de minimiser la composante motrice du sportif.

1) Quelles sont les grandes phases d'une action de frappe au baseball ? (1 point)
2) Pour quelle(s) raison(s) un entrainement des phases cognitives de cette action doit se faire en excluant la composante motrice du geste ? (2 points)
3) Proposez une méthodologie de mesure et d'entrainement de ces facteurs cognitifs. (2 points)

Sujet B : Serge VAUCELLE (10 points)

« Testing », « monitoring », « big data » inondent le domaine de l'entraînement sportif. Ces éléments impliquent la prise en compte des données de masse dans votre travail.

Repositionnez chacun de ces paramètres et, en présentant les outils que vous mobilisez, présentez un exemple concret de démarche qui permette de combiner une analyse de la tâche sportive et un contrôle des charges interne et externe de vos sportifs.

Session : 1

Année de formation : M2 EOPS

Intitulé et code de l'épreuve : SIESA1GM

Sciences du comportement et optimisation de la performance (UE 3P2)

Nom du responsable du sujet : Anne ILLE

Durée de l'épreuve : 2h00

~~Documents ou matériels autorisés~~

Documents non autorisés

Répondez aux questions ci-dessous en soignant la qualité de la rédaction et de la présentation.

1. Définissez les différentes catégories de feedbacks qui interviennent dans le contrôle du mouvement humain et donnez un exemple de chaque catégorie.

2. Quel est le rôle des feedbacks dans le contrôle du mouvement humain ?

3. Quels sont les effets des feedbacks ajoutés par l'entraîneur sur l'apprentissage ou l'optimisation des habiletés motrices ?

4. Quelles sont les prescriptions relatives à l'utilisation des feedbacks ajoutés afin de favoriser l'apprentissage et l'optimisation des habiletés motrices ?

5. Afin de prévenir les risques de blessures du genou, il est recommandé d'entraîner la technique de réception des sauts en visant une réduction du valgus du genou (facteur de risque biomécanique), avec comme finalité l'automatisation et le transfert de cette technique aux situations de compétition (Benjaminse, A., Gokeler, A. et al.,2015. Optimization of the Anterior Cruciate Ligament Injury Prevention Paradigm: Novel Feedback Techniques to Enhance Motor Learning and Reduce Injury Risk. *Journal of Orthopaedic & Sports Physical Therapy 45(3)*: 170-182). Dans un exercice de drop-jump, proposez trois types de feedbacks ajoutés favorisant l'acquisition d'une technique optimale de réception (réduction du valgus). Vous préciserez comment vous mettriez en œuvre les prescriptions issues des études scientifiques sur le feedback ajouté.

Année universitaire 2021/2022

Sujet examen

<u>Session</u> : 1ère session

<u>Année de formation</u> : Master 2 EOPS

<u>Intitulé et code de l'épreuve</u> : UE 3P3 – Apport des outils de quantification pour l'entraînement et la préparation physique – SIESA1HM

<u>Nom du responsable du sujet</u> : Serge VAUCELLE

<u>Durée de l'épreuve</u> : 2 heures

Documents et matériels non autorisés ☒

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Master 2 Année 2021-2022 session 1 module éducation santé

Sujet : Genolini Jean-Paul

2h sans document

L'intervention en éducation thérapeutique est fondée sur des modèles qui puisent leurs sources dans les approches cognitivo- comportementalistes ou constructivistes. Après avoir caractérisé ces approches vous montrerez, par comparaison, les intérêts et limites des celles-ci. Vous pouvez exemplifier vos propos par des expériences personnelles ou des exemples pris en cours.