Technicality of Noun-Noun Combinations in Sports Science Research Articles

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Abstract

The authors of this paper aimed to study the role of Noun-Noun Combinations (NNCs) in academic discourse, in a particular branch of sports science, exercise physiology. It began with the creation of an Exercise Physiology Research Article Corpus (EPRAC). The corpus, which consisted of 41 journal research articles in the discipline giving a corpus size of approximately 134,029 running words, was compiled. Nouns occurring at least three times in the corpus were selected for investigation, and found that they have a strong tendency to combine in NNCs, a process central to the creation of technicality in the corpus. A total of 2,010 NNCs types were identified, comprising more than 22% of all the word types in the corpus. These NNCs were classified by experts in the field according to how closely or exclusively they are related to the field of exercise physiology (how technical they are). It was found that over 75% of the NNCs are technical. Technical NNCs occurring at least three times were included in the Exercise Physiology Research Article Corpus Noun-Noun Combination List (EPRACNL). The list consists of 417 technical NNCs. The NNCs in the list are vital to sports science learners for academic texts comprehension especially research articles. They are also an essential part of sports science course designed to teach graduate students how to understand published research in this field.

Keywords: Noun-Noun Combinations, Vocabulary Classification, Sports Science, Exercise Physiology, English for Academic Purposes

บทคัดย่อ

งานวิจัยนี้มีจุดมุ่งหมายเพื่อศึกษาความสำคัญของคำนามผสมในสัมพันธสารทางวิชาการของสาขาสรีรวิทยาการออกกำลังกายซึ่งเป็นหนึ่งในสาขาวิทยาศาสตร์การกีฬา ขั้นตอนการวิจัยเริ่มจากการจัดทำคลังคำศัพท์ ซึ่งคลังคำศัพท์นี้ประกอบ ด้วยบทความวิจัยทางสรีรวิทยาการออกกำลังกายจำนวน 41 บทความและมีคำจำนวน 134,029 คำ คำนามที่มีความถี่อย่างน้อย 3 ครั้งขึ้นไปถูกเลือกมาทำการศึกษาโดยนำมาหาคำนามผสม ผลการศึกษาพบว่า คำนามกลุ่มนี้เมื่อรวมกันเป็นคำนามผสมแล้วมักเป็นคำนามผสมเทคนิค มีคำนามผสม

ทั้งหมดจำนวน 2,010 คำ ซึ่งมีอัตราส่วนมากกว่าร้อยละ 22 ของคำทั้งหมดในคลังคำศัพท์ คำนามผสมทั้งหมดถูกนำมาแยกกลุ่มเป็นคำนามผสมที่เป็นคำเทคนิคและไม่ใช่คำเทคนิคทางสรีรวิทยาการออกกำลังกายโดยผู้เชี่ยวชาญด้านสรีรวิทยาการออกกำลังกาย โดยการหาว่าคำนามผสมใดบ้างที่มีความหมายสัมพันธ์และสัมพันธ์โดยตรงกับสรีรวิทยาการออกกำลังกายและมีจำนวนมากน้อยเพียงใด ผลการศึกษาพบว่า ในจำนวนคำผสมทั้งหมดนี้มีคำผสมเทคนิคคิดเป็นอัตราส่วนมากกว่าร้อยละ 75 คำนามเทคนิคที่เกิดขึ้น 3 ครั้งได้รับการรวบรวมเข้าไว้ในรายการคำศัพท์คำนามผสมจากคลังคำศัพท์บทความทางสรีรวิทยาการออกกำลังกาย ในรายการคำศัพท์นี้ประกอบไปด้วยคำนามผสมเทคนิคเป็นจำนวน 417 คำ นั่นแสดงให้เห็นว่าคำนามผสมที่เกิดขึ้นในเอกสารทางวิชาการเฉพาะด้านนี้มีความสำคัญและรายการคำศัพท์นี้มีความจำเป็นในการอ่านเอกสารทางวิชาการของนักศึกษาสาขาวิทยาศาสตร์การกีฬาและสามารถนำไปออกแบบการเรียนการสอนสำหรับนักศึกษาระดับบัณฑิตศึกษาในการอ่านบทความทางวิชาการในสาขาวิทยาวิทยาศาสตร์การกีฬาด้วย

คำสำคัญ: คำนามผสม การแยกหมวดหมู่คำศัพท์ วิทยาศาสตร์การกีฬา สรีรวิทยาการออกกำลังกาย ภาษาอังกฤษสำหรับจุดมุ่งหมายทางวิชาการ

Introduction

An important policy of the Thai government is to promote exercise for health and sports for excellence (www.most.go.th/main/files/sp61.pdf). In the modern world where people would hope to live longer and be healthier, exercise science is employed for the general public to improve their health. As to the popularity of sports and exercise in Thailand, there are many sports competitions held at different levels. Whenever a sport competition is held, sports science is used to prepare athletes both physically and mentally for effective sport performance. Sometimes, sports and exercise science are combined; sometimes, the terms are used interchangeably. Because of the policy and popularity of sports and/or exercise, sports and/or exercise science is studied at many educational levels in many universities in Thailand. Sports and/or exercise science contains three main sub-disciplines which are exercise physiology, exercise biomechanics, and exercise psychology. However, exercise physiology is the core sub-discipline of sports science and all students in this field have to study this core course. Sports science is a science that originates in the West, and English plays a role in academic texts. English texts are used mostly in graduate sports science. However, Thai students encounter difficulty in using English texts, especially reading research articles which are academic texts written in an academic genre with specialized content.

Vocabulary

There are three main factors related to learning language: background knowledge, grammar, and vocabulary (Nation, 2001). However, vocabulary seems to play a role above the others. When vocabulary is studied, both single words and multi-word units which have a single unit of meaning are included (Lewis, 1993). A multi-word lexical unit or multi-word unit or collocation or noun phrase or word combination is when two or more words occur together. One of the word combinations used frequently in academic genres is the noun-noun combination. Hence, noun-noun combinations in sports and/or exercise science are the focus in this study.

Noun-Noun Combinations (NNCs)

Fabb (2001) proposed that noun+noun compounds or noun-noun combinations consist of a head noun and a modifying noun. The head noun, which is the second word in the combination, shows the broad referential class of the combination, while the modifying noun, which is the first noun, acts as the class modifier with some additional semantic constraints. Examples of NNCs which occur frequently in technical English are *fossil fuel*, *steam turbine*, *clock pulse*, and *wave function* (Linh, 2010). Besides the syntactic definition of NNCs, the semantic perspective is considered.

Role of NNCs

NNCs are used in large numbers in any discourse (Schmitt & Carter, 2004; Arnaud & Savignon, 1997). They occur in both general texts (Martin, 2003), and academic texts (Biber & Barbieri, 2007; Biber & Gray, 2010; Hyland, 2008; Linh, 2010; Ward, 2007; Wasuntarasophit, 2008). Martin (2001) stated that noun phrases, or NNCs in this study, occur mostly in all texts, especially academic texts. NNCs in science and technology disciplines such as chemical engineering (Ward, 2007) have a high occurrence. Wasuntarasophit (2008) demonstrated that in the technical and academic vocabulary of electrical engineering textbooks, noun phrases comprised 20.80% of the running words in the corpus. Biber and Barbieri (2007) mentioned that word combinations appear in every part of academic texts because of the characteristics of academic writing.

The next characteristic most often mentioned is the special meaning conveyed by NNCs (Arnaud & Savignon, 1997; Laufer, 1990; Pueyo & Val, 1996; Ward, 2007). Laufer (1990) pointed out that whole lexical units have special meanings and have more significance than single units. NNCs convey specific meanings which are used as technical terms because, when two words are combined, they convey the compact meaning of nouns (Pueyo & Val, 1996). NNCs help readers to understand the meaning in a specific text more than only single words do (Hyland, 2008). Therefore, NNCs should be learned for the full form of their meaning (Arnaud & Savignon, 1997). However, for people who do not know the context well it is difficult to interpret the meaning. Master (2003) mentioned that the meanings of NNCs should be decoded as a whole and not just the components.

As NNCs are of considerable significance, they should be studied. Importantly, learning NNCs units is very efficient and more accurate than learning individual words (Schmitt & McCarthy, 1997). NNCs help learners to be fluent in language (Hyland, 2008), in all skills (Kazemia, Katiraeib, & Rasekh, 2014), and in all types of texts (Vincent, 2013). Kasahara (2011) found that combinations enhance vocabulary learning. All previous notions mentioned above signify that NNCs are vital in word learning.

Schmitt and McCarthy (1997) showed that NNCs can help learners use language naturally and reach native-like fluency. Lewis (2000) significantly mentioned in relation to fluency that word combinations help us think or communicate quickly and effectively, because when we memorize, we do them as a word combination, and when we want to produce fluency in language, we produce it as a whole collocation and not as a single word. This is faster and more natural, and it is the way that native speakers of English use language. Consequently, learners will use the language well by memorizing and producing it in units of language that are much larger than a word (Crystal, 2003).

Adel and Erman (2012) investigated the use of English language lexical bundles, which are words that come or occur together, in academic writing by native and non-native English advanced learners. The results showed that the native speakers of English used more word combinations and that they were more varied than those used by non-native English speakers. Adel and Erman postulated that native speakers rely more on word combinations than non-native speakers do. Arnauld and Savignon (1997) conducted research on rare words and complex lexical units used by advanced learners. They reported that advanced learners did not perform differently from native speakers in the rare word test, but they performed at a lower level than native speakers in complex lexical items. Therefore, from Arnauld and Savignon’s study, it can be said that complex lexical bundles are difficult for non-natives because they cannot reach native-like proficiency in complex lexical bundles or word combinations.

Schmitt and McCarthy (1997) identified that the importance of collocations is that learners can store collocations in the forms in which they learn them, and then produce them in forms. The result is faster and more natural words. This way of storing and producing, as Nation (2001) put it, can enhance fluency and the appropriateness of language use. Lewis (2000) asserted that collocation makes thinking easier, and collocation makes learners understand complex ideas quickly. Ward (2007) revealed that teaching students to learn words groups, which are words occurring together, can enhance their reading. Kasahara (2011) examined the effects of learning known and unknown word combinations and single words in terms of the retention and retrieval of meanings. The results indicated that word combinations make for better retention and retrieval of meanings than single words. He claimed that word combinations can be remembered for longer than single words.

Quirk (1985) mentioned that scientific writing has a high proportion of noun phrases, therefore "…dealing with collocations helps tackle the difficulty of technicality caused by compression" (Ward, 2007, p. 25). Hyland and Tse (2007) stated that learning the whole word unit is better than learning single words. Lewis (2000) suggested that it is difficult to explain complex ideas, so they are often expressed lexically. Hyland (2008) proposed that the differences in multi-word units can be seen in different texts and disciplines. Ward (2007) investigated collocation and technicality in English for Academic Purposes (EAP) engineering and reported that phrases represent technicalization more than single words do, and that there was a high proportion of nouns in scientific writing. He also recommended that complex noun phrases are appropriate for learning. Alexander (1985) and Irujo (1986) claimed that learning multi-word units is vital for advanced learners.

The significance of NNCs cannot be avoided. NNCs can be learned faster and more easily. When speakers or writers know more word combinations, they can produce language naturally like native speakers. Furthermore, NNCs convey a discipline's specific meaning in specialized texts.

The significance of NNCs led the researchers in this study to investigate the role of NNCs in sports science texts because NNCs in specialized texts are worth learning for learners in specialized areas. NNCs convey the technical meanings which are the main content of the texts. Knowing the main content of the research articles in sports science facilitates learners' comprehension of texts. Moreover, creation of a list of technical NNCs for exercise physiology learners is needed in the field of sports science as they convey the main content of the texts which helps learners in their text comprehension. The NNCs in the list shows course designers, teachers, and learners what vocabulary learners need, and how much has to be learned. It prepares EAP learners before studying, and facilitates them while studying the content in order to help them learn effectively and efficiently.

The purposes of this study are: 1) to see the proportions of NNCs in Exercise Physiology Research Article Corpus (EPRAC); 2) to determine the technical NNCs in EPRAC; and 3) to create a technical NNCs list for sports science learners.

Methodology

The research method started from the corpus creation. A corpus is "a large collection of authentic texts that have been gathered in electronic form according to a specific set of criteria, which helps us understand the real language used in the authentic world" (Bowker & Pearson, 2002, p. 9).

Text selection

Exercise physiology is a main sub-discipline and core course of sports science, and therefore it is the focus of this research. It is the study of the body responses and adaptation to physical activities. The research articles which are in the exercise physiology field were selected from journals recommended by sports science students and their lecturers. The researchers interviewed sports science students and their lecturers about the sub-disciplines of sports science, what the exercise physiology components are, what types of texts the students use, and what journals the students usually use. Research articles related to the field of exercise physiology were chosen by looking at the key words and the abstracts. Therefore, the research articles containing keywords and abstracts about nutrition, energy, energy delivery, energy utilization, enhancement of energy capacity, energy performance, body composition, sports, exercise, and disease prevention were taking into consideration. There are 41 research articles which were collected from: 1) *Journal of Exercise Physiologyonline*, 2) *Physiology and Behavior*, 3) *Exercise Science and Fitness*, 4) *Psychology of Sports and Exercise*, 5) *Science and Sports*, 6) *Clinical Nutrition*, 7) *Physical Medicine and Rehabilitation*, and 7) *Journal of Science and Medicine in Sport*.

Text conversion into electrical form for corpus building

When the research articles had been selected based on the criteria mentioned above, they were converted into text files. The files were merged into a single file which is called the EPRAC. There are 134,029 word tokens and 8,787 word types in the corpus. The term "word tokens" refers to the total number of word forms in a text. The term "word types" refers to the different individual words in a text. After that WordLister of Word Smith Tools was employed to list all the word tokens from the corpus into frequency order. The word types occurring at least three times were selected for this investigation. NNCs were identified manually by employing the nouns occurring at least three times to form NNCs in the corpus. There are 2,010 NNCs in the corpus. Then, these 2,010 NNCs were classified into categories by using an adapted rating scale.

The adapted three steps rating scale for Noun-Noun Combinations' (NNCs') classification

This adapted rating scale for the NNCs' classification is adapted from the original rating scale of Chung and Nation (2004) as follows:

The adapted three steps rating scale to identify NNCs in the exercise physiology field.

Step1: NNCs are used inside and outside the field that meanings have no necessary relationship with exercise physiology e.g. *sea level, standard deviation*

Step 2: NNCs are used inside and outside the field that have a meaning related to the field of exercise physiology. They are NNCs in biology, chemistry, anatomy, physiology, sports/exercise, medical, and sports science. When they are used in exercise physiology, their meanings are related to exercise physiology e.g. *amino acid, blood cell,* and *plasma volume*.

Step3: NNCs have meanings specific to the field of exercise physiology, and they are used mostly in exercise physiology. They are not likely to be known in general language. They are about studying of functions of biological systems and how the body responds to exercise activities e.g. *endurance capacity*, and *exercise intensity*.

NNCs rated into steps 2-3 were classified as technical NNCs because their meanings are related or specific to the exercise physiology field, while NNCS rated into step 1 were classified as non-technical NNCs.

To ensure the reliability of the rating scale, inter-raters are needed to measure the consistency of the rating (Chung & Nation, 2004). Three specialists who are experienced in the exercise physiology field and have taught this course for more than 7 years rated 45 random NNCs (which is 15 NNCs from each step) by using the rating scales to check the rating reliability. When the inter-raters finished the rating, the reliability accuracy score of the rating was investigated and compared between the researchers and the three specialists to see the degree of agreement (Chung & Nation, 2003). Finally, the reliability was checked. The reliability value in each group was over 0.7 (Rosenthal, 1987); therefore, they are acceptable. This means that the researchers know the words well and can rate accurately and, hence, the researchers' rating is reliable.

Exercise Physiology Research Article Corpus Noun-Noun Combination List (EPRACNL) creation

When the reliability of the rating was confirmed, the NNCs falling into steps 2 and 3 were classified as technical NNCs because in step 2 their meanings related to exercise physiology, and in step 3 their meanings are specific to the field of exercise physiology which shows the technicality of the NNCs (Chung & Nation, 2004). The NNCs rated into step 1 were classified as non-technical NNCs. There are 1,523 technical NNCs and 487 non-technical NNCs. The technical NNCs occurring three times or more from the EPRAC are included in the EPRACNL.

Findings and Discussion

Proportions of NNCs in the corpus

There are 2,010 NNCs in the EPRAC which is 22.87% of all word types in the EPRAC. All NNCs were classified into the adapted three steps rating scale to identify the NNCs in the exercise physiology field. Details are shown below.

Table 1: Noun-Noun Combinations (NNCs) in the EPRAC

<table>
<tr><th>Step</th><th>Number of NNCs</th><th>Percentage</th><th>Classification</th></tr>
<tr><td>1</td><td>487</td><td>24.23%</td><td>Non-technical NNCs 24.23%</td></tr>
<tr><td>2</td><td>1,451</td><td>72.19%</td><td rowspan="2">Technical NNCs
75.77%</td></tr>
<tr><td>3</td><td>72</td><td>3.58%</td></tr>
<tr><td>Total</td><td>2,010</td><td>100%</td><td>100%</td></tr>
</table>

There are 487 NNCs or 24.23% of all NNCs in the EPRAC which are classified into step 1. The examples of step 1 NNCs in the EPRAC are *control group* (55 times), *standard deviation* (47 times), *video game* (36 times), and *sample size* (21 times).

There are 1,451 NNCs or 72.19% of all NNCs in the EPRAC which are classified into step 2. The examples of NNCs in step 2 are *heart rate*, *body mass*, *blood pressure*, *body weight*, *muscle damage*, *and muscle soreness.* The numbers of times that these NNCs occur are 244, 116, 95, 80, 73, and 72, respectively.

There are 72 NNCs, which is 3.58% of all NNCs in the EPRAC, in step 3. The examples of step 3 NNCs in the EPRAC are *balance performance*, *endurance training*, *exercise performance*, and *intensity exercise.*

NNCs rated into steps 2–3 were classified as technical NNCs because their meanings are related to and are specific to the exercise physiology field, while NNCs rated into step 1 were classified as non-technical NNCs. Therefore, 1,523 technical NNCs are found which comprise 75.77% of all the NNCs in the EPRAC. There are 487 non-technical NNCs which are 24.23% of all the NNCs in the EPRAC. This means that the technical NNCs occur more often than the non-technical NNCs in the EPRAC.

Technical NNCs in the corpus

The technical NNCs in the EPRAC are 1523. The 20 highest occurrences of technical NNCs in the EPRAC are as shown in Table 2:

Table 2: The 20 highest occurrences of technical NNCs in the EPRAC

NNCs	**FREQUENCY**	**NNCs**	**FREQUENCY**
heart rate	244	energy expenditure	158
body mass	116	blood pressure	95
body weight	80	muscle damage	73
muscle soreness	72	exercise intensity	65
exercise training	58	intensity exercise	51
risk factors	50	oxygen uptake	49
trial performance	46	blood lactate	45
power output	45	body fat	41
beta cell	40	blood glucose	40
exercise group	40	body composition	39

All NNCs occurring in the EPRAC are classified into non-technical and technical NNCs by using the adapted three steps rating scale. An outstanding finding is the very high proportion of technical NNCs in exercise physiology texts. The findings found that there are 2,010 NNCs in the EPRAC which is a very high number and which means that NNCs occur very often and play an important role in all disciplines (Quirk, 1985).

The proportion of the technical NNCs in the EPRAC is very large. There are 1,523 technical NNCs in the EPRAC which is 75.77% of all NNCs occurring in the EPRAC. This shows that NNCs tend to show technicality by the combination of two nouns. Technical NNCs occur more often than non-technical NNCs in the EPRAC (three times more). Nearly half of the non-technical NNCs, or 224 out of 487 NNCs, in the EPRAC are words related to research such as those relating to statistics, research processes, and research article writing. The exemplifications of the NNCs related to statistics are *standard deviation*, *meta analysis*, *standard error*, *confidence interval*, *effect size*, *covariance analysis*, and *regression analysis*. The exemplifications of the NNCs related to research processes are *sample size*, *control group*, *treatment group*, *study design*, *future research*, and *data collection*. NNCs related to conducting research form a high proportion because the EPRAC comes from the research article genre. The same genre shares the same purposes, structure, and constraints (Bhatia, 1993). Therefore, the same words are used in the same genre.

These high proportions of technical NNCs in the EPRAC support the studies of Biber and Barbeiri (2007), Biber and Gray (2010), Hyland (2008), Linh (2010), Ward (2009), and Wasuntarasophit (2008), that NNCs are used highly in academic and specific texts. Exercise physiology research articles are not exceptional because they have specialized content in two different academic genres. Moreover, they are used technically (Master, 2003).

Role of Technical nouns in technical NNCs

Though NNCs convey a single unit of meaning, each noun is important to the combination. The NNCs occurring highly always come from nouns with high occurrence as well.

The 15 highest frequency nouns with their occurrences in the EPRAC are *exercise* (1,830), *study* (579), *performance* (515), *training* (463), *time* (430), *energy* (402), *intensity* (394), *body* (393), *rate* (380), *subjects* (370), *muscle* (350), *studies* (338), *group* (336), *test* (331), and *activity* (327). *Exercise* is the most common single noun in the EPRAC, occurring 1,830 times. Of these occurrences, 657 are in NNCs. These NNCs are all classified as technical. The high frequency of these NNCs reinforces the point about the centrality of NNCs to technical writing and the need for learners to master not just the individual words, but the combinations in which they occur.

This phenomenon with *exercise* is common among the most frequent nouns in the corpus. Table 3 below shows the percentage of each of these nouns which are found in NNCs.

Table 3: The 15 highest frequency nouns with their occurrences and NNCs examples in the EPRAC

	Frequency of noun	Total number of occurrences in NNCs	Total Percentage of occurrences in NNCs	Examples
exercise	1830	657	35.90	exercise intensity 65 exercise training 58 intensity exercise 51 exercise group 40
study	579	10	1.72	fatigue study 7 lifting study 1 training study 1 exercise study1
performance	515	254	49.32	trial performance 46 balance performance 34 endurance performance 24 agility performance18
training	463	339	73.21	exercise training 58 resistance training 34 training activities 28 training exercises 22
time	430	104	24.18	cycling time 23 contact time 15 exercise time 14 time interaction 9
energy	402	273	67.91	energy expenditure 158 energy intake 27 energy balance 16 energy demand 13
intensity	394	188	47.71	exercise intensity 65 intensity exercise 51 training intensity 14 intensity profile 7
body	393	326	82.95	body mass 116 body weight 80 body fat 41 body composition 39
rate	380	286	75.26	heart rate 244 work rate 18 flow rate 16 pulse rate 1
subjects	370	10	2.70	overweight subjects 3 athlete subjects 2 exercise subjects 1 sports subjects 1

muscle	350	293	83.71	muscle damage 73 muscle soreness 72 muscle strength 22 muscle glycogen 16
studies	338	8	2.36	training studies 3 dose studies 2 intervention studies 1 tennis studies 1
group	336	51	15.17	exercise group 40 fatigue group 5 intensity group 1 training group 1
test	331	77	23.26	exercise test 23 cycling test 6 treadmill test 5 stress test 2
activity	327	68	20.79	enzyme activity 9 activity levels 5 intensity activity 5 activity behaviour 3

Technical nouns such as *exercise*, *performance*, *training*, *energy*, *intensity*, *muscle*, and *activity*, form the technical NNCs in the EPRAC. *Exercise* which is a technical noun forms many technical NNCs such as *exercise intensity*, *exercise training*, *exercise intervention*, and *exercise performance*.

Non-technical nouns can form both non-technical and technical NNCs, such as *study*, *time*, *group*, *subject*, *test*, *and rate. Study* forms non-technical NNCs such as *study design*, *study quality*, *study control*, *study participants*, and *study protocol.* The non-technical NNCs are related to research methods and design. *Rate* is a non-technical noun when it is standing alone; however, it is part of combinations of technical NNCs in sports science, an example of which is *heart rate*. *Heart rate*, which means the number of heart contractions per minute, occurs 244 times in the EPRAC.

When non-technical nouns or technical nouns form technical NNCs, they occur frequently in the sports science discipline such as in *exercise intensity* (65 times), *trial performance* (46 times), *exercise training* (58 times), *cycling time* (23 times), *energy expenditure* (158 times), *body mass* (116 times), and *muscle damage* (73 times) in the EPRAC.

Conclusion and Recommendations

The EPRACNL includes 417 technical NNCs from the corpus. The list consists of the technical NNCs occurring at least three times and these are recommended for sports science students to study as this minimum repetition indicates their significance. Coxhead (2000), Chujo and Utiyama (2006), and Ward (2009) mentioned that words occurring one time out of approximately 50,000 running words from the corpus are considered important to study. In this study, the corpus size is approximately 130,000 running words, therefore NNCs occurring at least three times are considered worth learning. There are 1,523 technical NNCs in the corpus. The lowest occurrence of the technical NNCs is one time, and the highest occurrence of the technical NNCs is 244 times. There are 417 technical NNCs which are 20.74% of all the NNCs in the EPRAC. The high occurrence of NNCs in the EPRAC obviously shows the role of NNCs. Consequently, they should be focused on and taught. The technical NNCs in the EPRACNL which convey the meanings related and specific to the exercise physiology field should be studied. The first 417 technical NNCs should be prioritized to be taught to sports science learners.

The interviews with the sports science graduate students and their teachers show that sports science learners who study exercise physiology need to learn the EPRACNL because they are required to read research articles. They need to learn more English vocabulary to expand their vocabulary for text comprehension. As exercise physiology learners have to read texts specific to their field, technical vocabulary is a central focus. Technical vocabulary is useful for specific purpose learners (Nation, 2001, 2008) because meanings are specific to the area of study. The EPRACNL comes directly from the exercise physiology corpora. The NNCs in the EPRACNL should be prioritized for teaching because they form regularly occurring vocabulary (Moon, 1997; Nation, 2001; Sinclair & Renouf, 1988) and contain the subject area content of exercise physiology. Examples of NNCs are *endurance test* and *performance response*. These NNCs show the content of exercise physiology clearly and allow readers to understand what the discipline is about. NNCs should be studied as well as they occur very often and convey special meanings specific to exercise physiology. Learning NNCs is a practical way for learners to understand specialized meanings more easily and achieve native-like language use (Nation, 2001). NNCs from the lists which occur frequently should be taught explicitly to exercise physiology learners. A pre-sessional course could help exercise physiology graduate students before taking the exercise physiology course, or an in-sessional course could also support their course learning.

The tasks and activities for teaching the vocabulary (Richards, 2001) can be: 1) word matching, 2) identifying NNCs from the context, and 3) connecting the two halves of a sentence to make a true statement.

Instruction: Match the noun-noun combination and its meaning

Noun-noun Combinations	***Meanings***
1) oxygen consumption	*a) the volume of oxygen that a human body uses in a given period of time for metabolism*
2) exercise intensity	*b) how much energy is expended when*

	doing exercise
3) energy expenditure	*c) the energy cost of body activities (Kent, 1994: p149)*
4) body mass	*d) the mass of the human body measured to the tenth of a kg when the subject is nude, or with clothing of a known mass so that a correction to nude mass can be made (Kent, 1994: p.64)*
5) heart rate	*e) number of heart contracts per minute*

Instruction: Identify NNCs from the context, and give the meanings of the NNCs

1) *Exercise*
   -Nutrition and exercise physiology share a natural linkage.
   -With this knowledge and perspective, the exercise specialist can critically evaluate claims about special nutritional supplements, including dietary modifications to enhance physical performance.
   -Endurance capacity during cycling exercise varied considerably, depending on what diet was consumed for 3 days before the exercise test.

2) *Performance*
   -Too often, individuals devote considerable time and effort striving to optimize exercise performance, only to fall short owing to inadequate, counterproductive, and sometimes harmful nutritional practices.
   -The high-carbohydrate diet improved endurance performance by more than three times that of the high-fat diet.
3) *Intensity*
   -Progressively increasing exercise intensity promotes continued bone deposition.
   -The magnitude of heart rate acceleration relates directly to physical activity intensity and duration.
4) *Damage*
   -Regular but excessive vitamin D consumption can cause kidney damage.
   -The addition of protein to the carbohydrate-containing beverage (4:1 ratio of carbohydrate to protein) may delay fatigue and reduce muscle damage compared with supplementation during exercise with carbohydrate only.
   -As discussed in Chapter 31, electrocardiography furnishes a vital diagnostic tool to uncover abnormalities in heart function, particularly abnormalities related to cardiac rhythm, electrical conduction, myocardial oxygenation, and tissue damage.
5) *Training*
   -Alterations in the bone's geometric configuration owing to long-term exercise training enhance its mechanical properties.
   -Successful nonpharmacologic treatment of athletic amenorrhea uses a four-phase behavioral approach plus diet and training interventions.
   - If additional research verifies these findings, and if changes in the hormonal milieu actually diminish training responsiveness and tissue synthesis, a low-fat intake may be contraindicated for optimal resistance training responses.

Instruction: Connect Part A and B to make 5 true statements

Part A

1) Carbon, hydrogen, oxygen, and nitrogen represent

2) Depleting carbohydrate reserves increases

3) Elite sport performance success requires

4) Type 2 diabetes results when the pancreas cannot

5). Patients with existing heart disease improve

Part B

a) the basic structural units for most of the body's bioactive substances.

b) protein catabolism during exercise

c) optimization of muscle fiber distribution

d) produce sufficient insulin to regulate blood glucose, causing it to rise
e) coronary blood flow (reducing myocardial ischemia during daily life) within 6 months by aggressively using drug and diet therapies that lower total blood cholesterol and LDL cholesterol.

These three types of tasks are recommended by Hutchinson and Waters (1987) and are suitable for English for Specific Purposes learners because they need to read exercise physiology research articles for their exercise physiology course and conducting their research.

The NNCs in the EPRACNL can help the students in all educational levels to expand their vocabulary and improve their reading comprehension. The NNCs in the EPRACNL also can provide guidelines for an exercise physiology course or vocabulary syllabus and for those who teach.

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Appendix

The Exercise Physiology Research Article Corpus Noun-Noun Combination List (EPRACNL)

417 NNCs and theirs occurrence

1. heart rate/244
2. energy expenditure /158
3. body mass/116
4. blood pressure/95
5. body weight/80
6. muscle damage/73
7. muscle soreness/72
8. exercise intensity/65
9. exercise training/58
10. intensity exercise/51
11. risk factors/50
12. oxygen uptake/49
13. trial performance/46
14. blood lactate/45
15. power output/44
16. body fat/41
17. beta cell /40
18. blood glucose/40
19. exercise group/40
20. body composition/39
21. waist circumference/38
22. balance performance/34
23. resistance training/34
24. resistance exercise/32
25. treadmill exercise/30
26. exercise program/29
27. exercise session /29
28. training activities/28
29. basketball players/27
30. exercise protocol/27
31. energy intake/27
32. oxygen consumption/27
33. soccer players/26
34. creatine kinase/24
35. endurance performance/24
36. cycling time/23
37. exercise test/23
38. blood samples/22
39. insulin resistance/22
40. muscle strength/22
41. training exercises/22
42. weight loss/22
43. sports medicine/21
44. tennis match/21
45. fluid intake/20
46. risk factor/20
47. endurance training/20
48. sprint performance/20
49. blood sample/19
50. cycle ergometer/18
51. exercise intervention/18
52. heart failure/18
53. program duration/18
54. skinfold thickness/18
55. tennis tournament/18
56. work rate/18
57. agility performance/18
58. lactate threshold/17
59. exercise duration/16
60. fitness level/16
61. flow rate/16
62. muscle glycogen/16
63. protein intakes /16
64. energy balance /16
65. exercise performance/16
66. cell death/15

67. contact time/15

68. arm exercise/14

69. exercise time/14

70. muscle protein/ 14

71. recovery period/14

72. interval training/14

73. training intensity/14

74. beta power/13

75. exercise bout/13

76. training period/13

77. energy demand/13

78. carbohydrate oxidation/12

79. exercise sessions/12

80. glycogen stores/ 12

81. interval cycling /12

82. muscle recovery/12

83. training sessions/12

84. baseline levels/11

85. carbohydrate intake/11

86. exercise intensities/11

87. pace factor/11

88. serum cortisol/11

89. alcohol consumption/10

90. caffeine supplementation/10

91. carbon dioxide/ 10

92. exercise capacity/10

93. exercise programs/10

94. fat diet/10

95. intermittent exercise/10

96. lipid profile/10

97. pressor test/10

98. endurance cycling/10

99. adolescent girls /9

100. amino acid/9

101. baseline values /9

102. energy restriction/9

103. enzyme activity/9

104. exercise bouts/9

105. exercise groups/9

106. exercise period/9

107. exercise tests/ 9

108. fat diets/9

109. insulin secretion/9

110. knee extensors/9

111. muscle function/9

112. muscle mass/9

113. protein supplement/9

114. rest period/9

115. time interaction/9

116. cycling performance/9

117. motor performance/9

118. balance tests/8

119. blood cell/8

120. brain injury/8

121. cycling exercise/8

122. disease risk/8

123. exercise characteristics/8

124. exercise hypotension/8

125. exercise tolerance/8

126. fat oxidation/8

127. protein synthesis/8

128. run time/8

129. slalom canoeists/8

130. sport drink/8

131. sports shooters /8

132. sprint effort/8

133. training program/8

134. water intake/8

135. task adaptation /8

136. balance recovery/7

137. body height/7

138. carbohydrate supplement /7

139. countermovement jump/7

140. density lipoprotein/7

141. exchange ratio /7

142. exercise dose/7

143. exercise protocols/7

144. fat mass/7

145. fatigue study/7

146. fitness levels/7

147. food intake/7

148. heart disease/7

149. intensity profile /7

150. leg press/7

151. male cyclists/7

152. mood states/7

153. muscle fatigue/7

154. muscle groups/7

155 muscle injury/7

156. nutrition institute/7

157. rehabilitation program/7

158. saliva samples/7

159. sport shooters/7

160. sprint time/7

161. superoxide dismutase/7

162. training effects/7

163. training session/7

164. energy expenditures/7

165. amino acids/6

166. analysis system/ 6

167. assay kit/6

168. baseline appointment/6

169. bench press/6

170. blood collection /6

171. body strength/ 6

172. boxing condition/6

173. calorie restriction/6

174. cycling test/6

175. exercise conditions/6

176. exercise frequency/6

177. exercise measurements/6

178. handball players/6

179. insulin sensitivity/6

180. left arm/6

181. liver glycogen/6

182. motor behavior/6

183. protein intake/6

184. rest ratio/6

185. serum testosterone/6

186. slalom canoe/6

187. stability index/6

188. testosterone concentration /6

189. transition speed/ 6

190. endurance athletes/6

191. endurance exercise/6

192. exercise physiologist/6

193. performance power/6

194. acids consumption/5

195. activity levels/5

196. antioxidant enzymes/5

197. blood lipids/5

198. energy value/5

199. exclusion criteria/5

200. exercise interventions/5

201. exercise prescription/5

202. exercise results /5

203. exercise values /5

204. fat weight/5

205. fatigue group/5

206. fatigue index/5

207. glucose concentration/5

208. glucose homeostasis/5

209. hand grip/5

210. human saliva/5

211. lactate concentration/5

212. lactate dehydrogenase/5

213. leg extensor/5

214. macronutrient intakes/5

215. motor skills/5

216. muscle fibers/5

217. protein requirements/5

218. rest day/5

219. right hand/5

220. run times/5

221. speed strength /5

222. sports competitions/5

223. training load/5

224. treadmill run/5

225. treadmill speed/5

226. treadmill test/5

227. treatment effect /5

228. work output/5

229. force development/5

230. intensity activity /5

231. intensity exercises/5

232. muscle performance/5

233. performance time/5

234. acid concentration/4

235. adolescent boys /4

236. adult population/4

237. alanine aminotransferase/4

238. alcohol intake/4

239. aspartate aminotransferase/4

240. athlete men/4

241. average consumption/4

242. baseline value/4

243. blood pressures/4

244. body builders/4

245. body temperature/4

246. capillary blood/4

247. carbohydrate drink/4

248. carbohydrate meal/4

249. cardiolocomotor synchronization/4

250. cholesterol levels/4

251. coronary artery /4

252. cortisol concentration/4

253. creatine phosphokinase/4

254. cycle time/4

255. distance runners/4

256. ear lobe/4

257. energy supplementation/4

258. exercise condition/4

259. exercise effects/4

260. exercise measurement/4

261. exercise recovery/4

262. exercise transition/4

263. fitness parameters/4

264. fitness test/4

265. fluid volume/4

266. health survey/4

267. heart monitor/4

268. immune system/4

269. impedance analysis/4

270. insulin concentration/4

271. intensity profiles/4

272. intermittent model/4

273. intermittent protocol/4

274. knee angle/4

275. knee flexion/4

276. macronutrient requirements/4

277. maltodextrin solution/4

278. memory impairment/4

279. nitrogen balance/4

280. oxygen species/4

281. recovery measurements/4

282. recovery time/4
283. saliva sample/4
284. sample collection/4
285. sports performance/4
286. sports training /4
287. squat jump/4
288. strength loss/4
289. strength tests/4
290. strength training/4
291. stroke volume /4
292. task demands/4
293. training effect/4
294. training experience/4
295. training regime/4
296. training rigor/4
297. training status /4
298. treadmill velocity/4
299. velocity regression/4
300. balance measurements/4
301. balance system/4
302. energy requirement/4
303. gas exchange/4
304. intensity training/4
305. match performance/4
306. performance tests/4
307. performance times/4
308. performance variable/4
309. activity behaviour/3
310. activity participation/3
311. alkaline phosphatase/3
312. antioxidant capacity/3
313. antioxidant system/3
314. balance beam/3
315. balance test/3
316. baseline risk/3
317. basketball team/3
318. beta activity/3
319. blood flow/3
320. blood lipid/3
321. body fluid/3
322. body fluids/3
323. brain activity /3
324. breath system/3
325. carbohydrate supplements /3
326. cholesterol intake/3
327. cycle load/3
328. deoxynucleotidyl transferase/3
329. dismutase activity/3
330. dyspnea scores/3
331. elbow flexors/3
332. enzyme levels/3
333. exercise levels/3
334. exercise meals /3
335. exercise physiologists/3
336. fat intake /3
337. fatigue condition/3
338. female athletes/3
339. fitness characteristics/3
340. food consumption/3
341. foot position/3
342. frequency band/3
343. frequency bands/3
344. frequency domain/3
345. glucose levels/3
346. glucose tolerance/3
347. glutamyl transferase/3
348. glycogen synthesis/3
349. handball game/3
350. health benefits/3
351. health care/3
352. health history/3
353. health outcomes/3

354. heart association/3

355. heart level/3

356. hydrogen peroxide/3

357. immune responses/3

358. impact forces/3

359. insulin function/3

360. intensity intermittent/3

361. intensity levels/3

362. judo groups/3

363. kidney disease/3

364. knee joint/3

365. leg extension/3

366. leg fatigue/3

367. limb exercises /3

368. lipid peroxidation/3

369. locomotor activity/3

370. match players/3

371. moderator correlations/3

372. mood dimensions/3

373. muscle action/3

374. muscle contraction/3

375. night sweats/3

376. nutrient intake /3

377. overweight subjects/3

378. performance benefit/3

379. performance variables/3

380. placebo effect/3

381. placebo protein /3

382. plasma corticosterone/3

383. plasma glucose /3

384. practice effect/3

385. program appointment/3

386. protein diet/3

387. protein oxidation/3388. pulse pressure/3

389. quadriceps muscles/3

390. reaction time/3

391. recovery periods/3

392. recovery processes/3

393. rehabilitation patients/3

394. resistance exercises/3

395. serum hormones/3

396. serum samples/3

397. slalom canoeist/3

398. soccer match/3

399. soccer training/3

400. speed test/3

401. sport competence/3

402. sports performers/3

403. sprint times/3

404. stress adaptation/3

405. tennis players/3

406. tournament players/3

407. training run/3

408. training studies/3

409. treatment type /3

410. volleyball players/3

411. weight training/3

412. work load/3

413. endurance runners/3

414. energy production/3

415. gas exchanges/ 3

416. intensity run/ 3

417. soccer performance/3