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Content Analysis of Patent Applications for Strength Training Equipment Filed in the United States Before 1980

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Abstract

Nuzzo, JL. Content analysis of patent applications for strength training equipment filed in the United States before 1980. *J Strength Cond Res* 35(10): 2952–2962, 2021—Strength training history is an emerging academic area. The aim of the current study was to describe quantitatively the history of inventions for strength training equipment. Content analysis was conducted of patent applications for strength training equipment filed with the U.S. Patent and Trademark Office before 1980. Applications were identified using relevant keyword searches in Google Patents. A total of 551 patent applications were analyzed. The earliest application identified was filed in 1860. Applications never exceed 6 per year until 1961 after which applications increased substantially, with a peak of 54 in 1979. Men invented 98.7% of all strength training devices. Lloyd J. Lambert, Jr. was the most prolific inventor, with 10 inventions. Types of inventions included mobile units (34.5%), stationary machines (27.9%), dumbbells (16%), racks or benches (8.0%), barbells (6.7%), and Indian clubs (3.8%). Common features included seats or benches (18.7%), cable-pulley systems (15.1%), weight stacks (8.2%), weight trays (4.5%), and cams (2.2%). Common types of resistance included weights or plates (33.2%), springs (11.6%), friction (9.1%), elastic bands (5.3%), and hydraulic (3.8%). Proposed invention benefits included adjustable resistance (37.4%), inexpensive (36.1%), simple to use (32.8%), compact design or easy storage (27.0%), multiple exercise options (26.1%), safety and comfort (25.4%), effectiveness (23.6%), portability (20.5%), adjustable size (15.8%), sturdiness or durability (15.8%), home use (13.6%), and light weight (13.6%). Certain aspects of strength training equipment have evolved over time. However, overall purposes and benefits of inventions have remained constant (e.g., affordability, convenience, personalization, safety, and effectiveness).

Key Words: intellectual property, muscle strength, patents, physical fitness, resistance training

Introduction

Strength training is physical exercise that involves repeated muscle contractions against external resistance or one's body mass with the intent of increasing muscle strength. Adoption of strength training by many individuals in a society is a relatively new phenomenon and has been made possible, for one, by the development and production of strength training equipment. The history of strength training is an emerging area of scholarly inquiry (7,11,17,18,21–24), but the topic of strength training equipment and its history has garnered relatively little attention (20).

One way to explore the history of strength training equipment is to study the content of patent applications. A patent is an intellectual property right for an inventor (U.S. Constitution, Article 1, Section 8, Clause 8). In the United States, patent applications are usually submitted by inventors and their patent attorneys. The application often includes a drawing of the invention, a description of the invention's purpose, a description of how the invention advances existing technology, and a description of how the structural components of the invention operate and allow for its use. After a patent is granted by the

U.S. Patent and Trademark Office, the application becomes publicly available. Thus, patent applications for strength training equipment can be analyzed to inform the history of strength training. Therefore, the aim of the current study was to inform the history of strength training equipment by analyzing and describing the contents of patent applications for strength training equipment filed before 1980.

Methods

Experimental Approach to the Problem

To describe inventions for strength training equipment, several steps were taken. First, a search was performed on the Google Patents website to identify patent applications that were submitted to the U.S. Patent and Trademark Office before 1980. Second, the identified applications were assessed to determine whether the inventions were designed to improve muscle strength or measure muscle strength. Third, applications that met eligibility criteria underwent content analysis. Before the study, a list of characteristics of inventors and inventions was generated. The purpose of the content analysis was then to determine whether the inventors or inventions exhibited these characteristics.

Procedures

Search for Inventions. In October 2020, a search for inventions for strength training was performed on the Google Patents website

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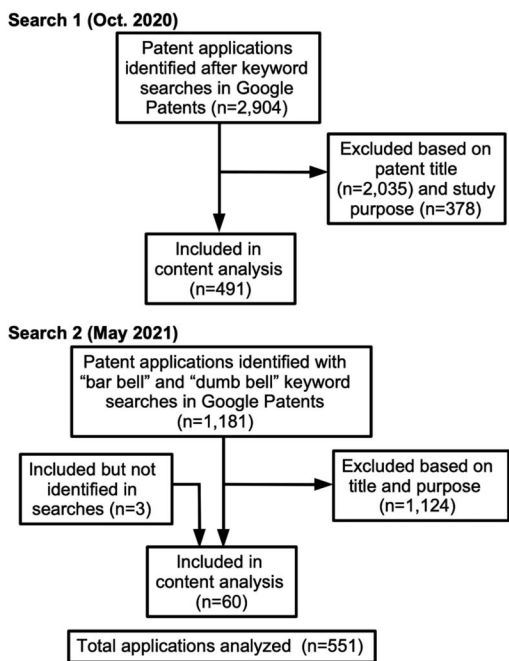


Figure 1. Flow diagram of steps used to identify patent applications eligible for content analysis. A total of 551 applications were analyzed.

(patents.google.com). The search was limited to patent applications written in English and filed with the U.S. Patent and Trademark Office before 1980. The year 1979 was chosen as an end date to coincide with another recent historical analysis (11). The keyword search entered into Google Patents was (“muscle strength”) OR (“physical fitness”) OR (“barbell”) OR (“dumbbell”) OR (“Indian club”) OR (“exercise apparatus”) OR (“exercise device”) OR (“exercise machine”) OR (“isometric exercise”) OR (“isometric exerciser”) OR (“isokinetic exercise”) OR (“isokinetic exerciser”) OR (“isotonic exercise”) OR (“isotonic exerciser”) OR (“resistance exercise”) OR (“resistance training”) OR (“strength training”) OR (“weight lifting”) OR (“weight training”) country:U.S. before: filing: 19791231 language:ENGLISH type: PATENT. The Google Patents website captures the search results in a Microsoft Excel spreadsheet. The spreadsheet includes the following information: patent identification number, patent title, patent assignee name, patent inventor name, patent application filing date, patent application grant/ approval date, a link to the full text of the patent application, and a link to a picture of the invention. In the current study, the spreadsheet was downloaded to a personal computer, and applications identified in the search were screened for eligibility.

Eligibility was determined in 2 steps. First, titles of patents were screened. If the title of the application implied the patent was not related to physical exercise (e.g., US-3644301-A “1-methylcyclopropene copolymers” or US-4161998-A “Fire escape device”), then the application was excluded from the study. Second, patent purpose was evaluated. To be included in the current study, the patent needed to be designed to either measure muscle strength in humans or be used in physical exercise to improve muscle strength in humans (i.e., strength training). Strength training was defined as repeated volitional muscle contractions against external resistance or one’s own body mass with the purpose of improving muscle strength, enhancing muscle “tone,” “exercising muscle,” etc. Types of patents excluded at this stage included sports equipment, leisure toys and games, exercise

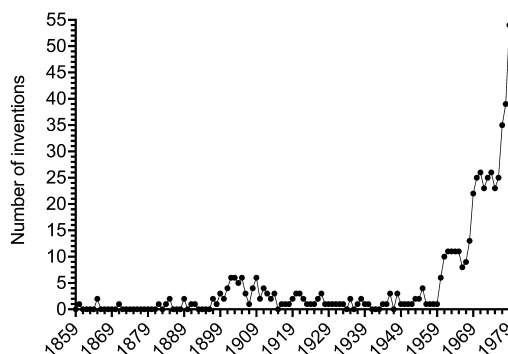


Figure 2. Number of inventions for strength training equipment before 1980 by year. The first patent application identified in the search was filed in 1860. Notable increases in application numbers occurred in the 1960s and 1970s.

equipment for animals, exercise equipment used primarily to improve cardiovascular health (e.g., treadmills or bicycles), and devices that did not involve volitional control of muscles (e.g., massagers, vibration machines, passive movement devices, or blunt force contact of an object onto the muscle).

In May 2021, a second search of Google Patents was performed as follows: (“bar bell”) OR (“dumb bell”) country:U.S. before: filing: 19791231 language: ENGLISH type: PATENT. This search was conducted after a peer reviewer pointed out that some patent applications for dumbbells and barbells from the 1800s were not identified in the original search. In the 1800s and early 1900s, the words “dumbbell” and “barbell” often included spaces within them (i.e., “dumb bell” and “bar bell”). Thus, the original search, which did not include versions of these words with spaces between them, did not identify early patent applications for dumbbells, barbells, or applications that referenced to dumbbells or barbells. Finally, the patent applications filed in the 1800s by George B. Windship (US-46413-A), D.P. Butler (US-48514-A), and Samuel B. Stockburger (US-405128-A) were included in the study, although they were not identified by either of the 2 searches performed.

Table 1
Count and percent of patent applications for strength training equipment by decade and the mean, minimum, and maximum number of days between application file and approval dates (application processing days) by decade.

Decade filed	Applications		Application processing days			
	Count	%	Mean	SD	Min	Max
1860–1869	3 (0.5)	0.5	n/a	n/a	n/a	n/a
1870–1879	1 (0.2)	0.2	n/a	n/a	n/a	n/a
1880–1889	5 (0.9)	0.9	133.8	102.7	53	306
1890–1899	9 (1.6)	1.6	335.0	238.7	104	841
1900–1909	43 (7.8)	7.8	304.3	178.7	89	785
1910–1919	19 (3.4)	3.4	452.2	338.4	101	1,377
1920–1929	18 (3.3)	3.3	587.2	393.7	256	1,800
1930–1939	10 (1.8)	1.8	647.8	328.0	223	1,158
1940–1949	10 (1.8)	1.8	1,118.5	630.3	440	2,110
1950–1959	20 (3.6)	3.6	960.2	271.0	433	1,342
1960–1969	112 (20.3)	20.3	993.4	304.3	288	1,966
1970–1979	301 (54.6)	54.6	713.6	263.1	244	1,860
Total	551 (100.0)	100.0	729.2	349.8	53	2,110



Figure 3. Number of inventions for strength training equipment before 1980 by state. Not presented are the 6 inventions from individuals who resided in Washington, DC or the 53 inventions by individuals who resided outside of the United States.

Data Analyses

Patent applications that met eligibility criteria underwent content analysis. Before the study, a list of variables of interest was generated. The purpose of the analysis was to determine whether the inventors or inventions exhibited these characteristics. For each patent application, the following information, which was not part of the Google Patent spreadsheet, was extracted or computed: patent purpose (measurement or training), year filed, decade filed, year granted, wait days (i.e., number of days between patent file and grant dates), inventor sex, inventor geographic location, equipment type (dumbbell; barbell; Indian club; rack or bench; stationary machine; mobile unit; implement that was not a dumbbell, barbell, or Indian club; or accessory piece or other devices), invention design features (cable and pulley, cam, display element, electricity, illumination element, seat or bench, weight stack, weight tray, or wheels), invention resistance type (bands or elastic elements, body mass, friction, hydraulic, isometrics against immovable resistance, motor-driven undefined, pneumatic, springs, water, weights or plates, or multiple types), invention structural adjustability, target body area or muscle group (head or neck only, upper-body only, lower-body only, trunk only, or multiple body areas), posture assumed while using the invention (lying only, seated only, standing only, or multiple postures), demographic groups mentioned in the patent application (athletes and sports performance, patients and rehabilitation, general adult and physical fitness, youth and physical fitness, women and physical fitness, or military and physical fitness), sports or performance areas mentioned in the patent application (arm wrestling, golf, football, musical performance, running or sprinting, skiing, swimming, or tennis), and rationale for the invention (athletics, general fitness, measurement, military, or rehabilitation).

The first name of the inventor was used to determine their sex. In the United States, many first names are assigned almost universally to one sex or another (e.g., James, John, Robert, Michael, William, David, and Richard are primarily assigned to men) (26). Thus, inventor sex was determined by common experience with names and then supported by reference to either U.S. census data on first names (26) or Internet searches of a first name and whether it is more commonly used as a male or female name. Similar approaches have been used in other studies (8,9,15,19). If a first name was neither obviously male nor obviously female a conservative approach was taken to label inventor sex as “unknown.”

For equipment type, stationary machines were those which, because of their larger size or heavier weight, were intended to be used in a given location (e.g., weight stack machines). Mobile units were those which, because of their smaller size or lighter weight, were portable and could be used in a variety of locations (e.g., finger-strengthening or grip-strengthening devices). In addition, mobile units typically consisted of some structural piece from which the resistance was attached. This distinguished mobile units from implements, such as dumbbells, barbells, and Indian clubs, which have little or no distinction between a structure base and a resistance. Barbells and dumbbells consisted of bars with bells or weights on the 2 ends of the bar. Barbells consisted of a longer bar held in both hands, whereas dumbbells consisted of a shorter bar held in one hand. Indian clubs are also held in one hand, but they consisted of a handle rather than a bar and most of the weight is located on one side of the handle.

The final variable assessed in the patent applications was the inventor’s proposed objectives or technological advancements. The objectives or advancements tabulated were (a) adjustable resistance, (b) adjustable size, (c) aesthetically pleasing, (d) can be used at home or in office, (e) can be used to measure muscle strength, (f) compact design or easily stored, (g) improved safety or comfort, (h) inexpensive or economical to manufacture, (i) light weight, (j) more effective than existing devices, (k) multiple exercises can be performed, (l) no supervision is required to use invention, (m) portable, (n) quieter than existing devices, (o) serves multiple functions, (p) simple or easy to use, and (q) sturdy, durable, or rugged. To aid in identification of these objectives, patent applications were opened in Adobe Acrobat Reader, and keyword searches were performed for relevant terms (e.g., “adjust,” “cost,” “easy,” “home,” “portable,” and “simple”). In addition, a patent application was deemed to have these objectives only if the objectives were stated explicitly in the application. In most cases, these objectives were stated in the introduction of the patent applications, but some were presented in other parts of the applications.

A few notes on the analysis require clarification. First, assumptions were not made about the purpose of an invention beyond that which was stated explicitly by the inventor or which could be logically concluded by the drawings in the application. For example, both upper-body and lower-body exercises can be performed with dumbbells, and these exercises can be performed from standing, seated, or lying postures. However, when assessing the body areas targeted by dumbbell inventions, it was not assumed the dumbbell was designed for both upper-body and lower-body exercise nor was it assumed that the dumbbell was intended to be used in

Table 2**Individuals who, before 1980, filed 3 or more patent applications for strength training equipment that were later granted.**

Inventor name	Year filed	Patent number	Patent name
Calvert, Alan	1902	US-702356-A	Bar-bell
	1908	US-907965-A	Dumb-bell and the like
	1911	US-1044018-A	Dumb and bar bell and ring-weight
Sandow, Eugen	1900	US-654097-A	Dumb-bell.
	1913	US-1123570-A	Combined toy and physical-culture apparatus.
	1913	US-1229658-A	Dumb-bell.
Newman, Louis B.	1948	US-2680967-A	Apparatus for measuring muscle strength
	1953	US-2763936-A	Apparatus for testing muscles
	1954	US-2784592-A	Apparatus for testing muscles
Zinkin, Harold	1957	US-2932509-A	Body exercising apparatus
	1960	US-3116062-A	Exercising apparatus
	1970	US-3649008-A	Hand and wrist exerciser device
	1970	US-3653659-A	Wrist exerciser device
	1971	US-3743282-A	Weight training device
LaLanne, Jack	1966	US-3438627-A	Weight-lifting device
	1970	US-3647209-A	Weight lifting type exercising device
	1970	US-3752473-A	Weight lifting type exerciser with indicator
Henson, Glen E.	1968	US-3550449-A	Exercising device for isometric and isotonic exercises
	1969	US-3640530-A	Exercise apparatus
	1973	US-3896672-A	Exercise apparatus
	1975	US-4041760-A	Exercise apparatus
Proctor, Richard L.	1969	US-3640525-A	Frictional resistant-type exercise machine with waist-level-mounted oscillatable...
	1969	US-3640527-A	Weight resistant chest exercising device
	1969	US-3640528-A	Pull-type variable weight exercising device
	1971	US-3746338-A	Movable weight type exercising
	1970	US-3861215-A	Exercising apparatus simulating weight lifting
Bradley, Robert F.	1971	US-3785644-A	Pull type exercising device having with frictional resistance to pulling
	1977	US-4138106-A	Weight training apparatus
	1972	US-3771785-A	Weight usable in a barbell assembly
Speyer, Henning J.	1972	US-3913908-A	Barbell having a detachably mounted weight supporting bar
	1973	US-3825253-A	Barbell with removable weights
	1972	US-3848467-A	Proportioned resistance exercise servo system
Flavell, Evan R.	1973	US-3869121-A	Proportioned resistance exercise servo system
	1976	US-4082267-A	Bilateral isokinetic exerciser
	1978	US-4261562-A	Electromagnetically regulated exerciser
Deluty, Michael J.	1974	US-3885789-A	Exercising device
	1975	US-3995853-A	Exercising device
	1975	US-4010948-A	Pull type friction exercising device
	1977	US-4114875-A	Friction type exercising device
Keiser, Dennis L.	1976	US-4050310-A	Exercising apparatus
	1977	US-4257593-A	Pneumatic exercising device
	1978	US-4227689-A	Exercising device including linkage for control of muscular exertion required...
	1975	US-3971555-A	Multipurpose body exercising machine
Mahnke, Parker E.	1977	US-4101124-A	Pull type exercising apparatus
	1978	US-4199139-A	Exercising apparatus
	1977	US-4149714-A	Seated weight lifting leg press exercise machine
Lambert Jr., Lloyd J.	1978	US-4195834-A	Vertical shoulder and lateral shoulder exercise machine
	1978	US-4200279-A	Leg extension, leg curl, hip, thigh, back and buttocks machine
	1978	US-4373717-A	Wrist curl machine
	1979	US-4236712-A	Standing calf exercise machine
	1979	US-4239210-A	Arm curl machine
	1979	US-4311305-A	Chest and bust machine
	1979	US-4322071-A	Standing vertical leg curl
	1979	US-4349191-A	Abdominal sidebend machine-upper
	1979	US-4349192-A	Counterbalanced weight system
	1977	US-4098502-A	Multi purpose exercise bench
Faust, Reginald O.	1979	US-4249726-A	Exercise bench safety device
	1979	US-4262901-A	Safety device for use in bar bell exercises and the like
	1971	US-3726522-A	Combination of a barbell with weight and collet device
Silberman, Ira J.	1979	US-4302005-A	Laterally pivoted weight training device
	1979	US-4316609-A	Bench mounted weight lifting exerciser

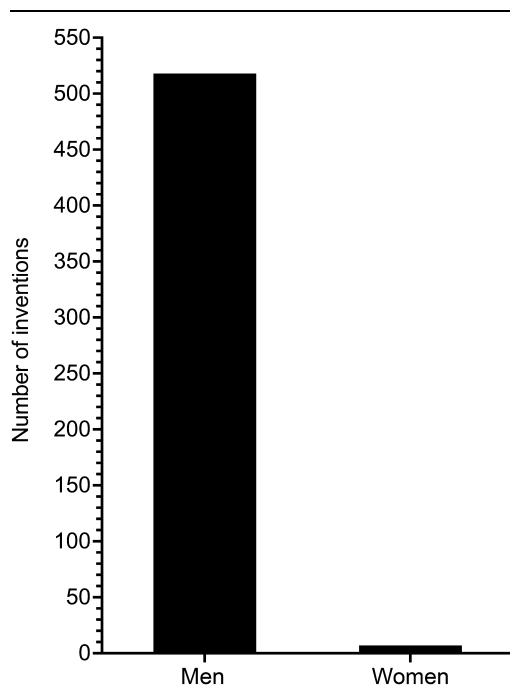


Figure 4. Number of inventions for strength training equipment before 1980 by men and women. Not presented are the 26 inventions for which inventor sex could not be determined.

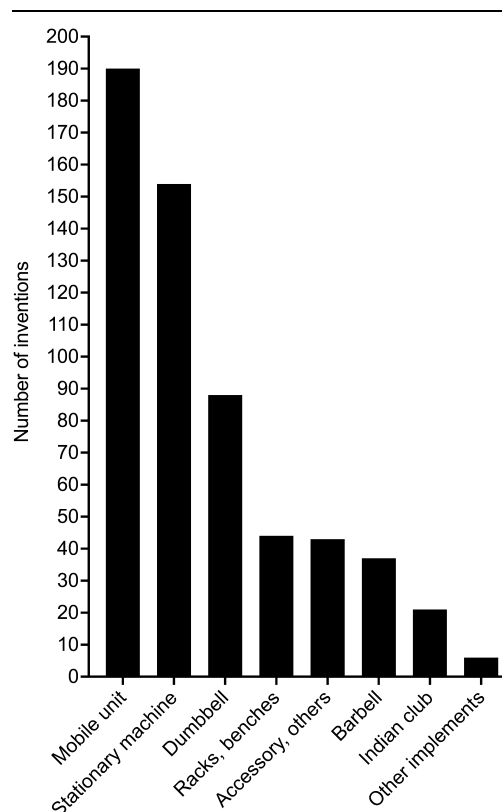


Figure 5. Number of inventions for strength training equipment before 1980 by general invention type.

particular postures. Instead, only the inventor’s statements were analyzed. If no statements on such variables were made by the inventor, then the variable was classified as “unclear” (or “n/a” depending on the invention and variable assessed). This ensured contemporary standards or experiences with exercise were not projected into the past.

Second, the notion of adjustable resistance was applied to strength measuring devices and strength training devices. In the case of strength measuring devices, this simply meant that the device was sensitive to, and able to record, various strength levels.

Third, 3 inventions did not meet the inclusion criteria as being either a strength measuring device or a strength training device but were still included in the analysis. These 3 inventions were Indian clubs that were illuminated and designed for use in shows and exhibitions (US-688599-A, US-744348-A, and US-1676689-A). They were included in the analysis for the sake of completion of the historical record on Indian clubs because these devices represent an important component of the history of strength training (20).

Statistical Analyses

SPSS version 27 (IBM, Armonk) was used to generate frequencies for categorical variables and descriptive statistics for continuous data. Descriptive statistics included means, standard deviations (SDs), minimums, and maximums. A list of applications included in the analysis is available on the Open Science Framework (12).

Results

Number of Inventions and Waiting Times

A total of 551 patent applications were eligible for content analysis (Figure 1). The earliest application identified in the search was filed in 1860. The number of applications filed per year did not exceed 6 until 1961 (Figure 2). The greatest number of patent applications

filed in a given year occurred in 1979, with 54 applications filed. The 1960s and 1970s were associated with the greatest number of applications (Figure 2 and Table 1). The mean number of days between file and approval dates was 729.2 ± 349.8 days (range: 53–2,110 days), with patents approved more quickly in the late 1800s and early 1900s compared with 1940 to 1979 (Table 1).

Characteristics of Inventors

Of the 551 patents applications, 498 applications (90.4%) were filed by individuals residing in the United States (Figure 3) and 53

Table 3
Selection of types of strength training equipment inventions and invention features by decade.

Decade	Dumbbells	Barbells	Indian clubs	Weight stacks	Cams
1860–1869	3	0	0	0	0
1870–1879	1	0	0	0	0
1880–1889	4	0	1	0	0
1890–1899	5	1	4	0	0
1900–1909	29*	1	9*	1	0
1910–1919	15	5	3	0	0
1920–1929	8	2	2	1	0
1930–1939	3	0	2	0	0
1940–1949	1	4	0	0	0
1950–1959	5	4	0	0	0
1960–1969	3	7	0	7	0
1970–1979	11	13*	0	36*	12*
Total	88	37	21	45	12

*Decade in which that type of invention or invention feature was most frequently included in patent applications.

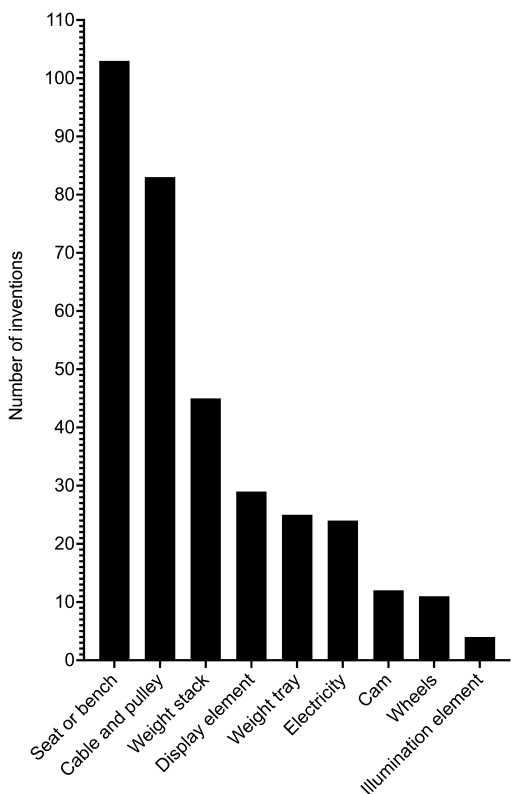


Figure 6. Number of inventions for strength training equipment before 1980 that included certain design features.

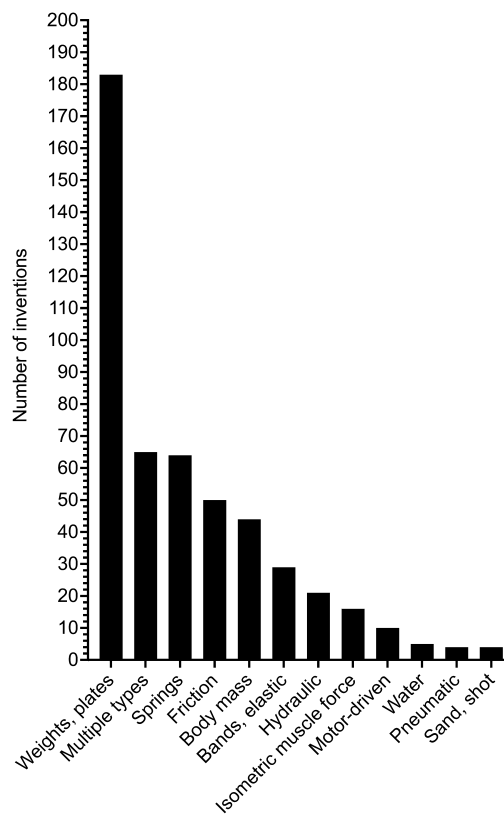


Figure 7. Number of inventions for strength training equipment before 1980 that included certain forms of resistance. “Multiple types” describes equipment in which multiple forms could be used to create resistance, such as dumbbells that involve a spring grip or a barbell whose bells could be filled with water, sand, or shot.

applications (9.6%) were filed from individuals residing outside of the United States. Of the 53 international applications, 15 were filed by individuals residing in Canada, 12 were from individuals in England, 6 were from individuals in Germany, 4 were from individuals in each of France and Switzerland, and 2 were from individuals in each of Argentina, Italy, Japan, and Sweden. One patent application was submitted from individuals residing in each of the following countries: Austria, Haiti, New Zealand, Norway, Scotland, South Africa, and Spain.

Some individuals invented multiple strength training devices. The most prolific inventor was Lloyd J. Lambert, Jr, who between 1977 and 1979 submitted 10 patent applications (Table 2). In addition, most strength training equipment was invented by men (Figure 4). Men submitted 518 of the 525 applications (98.7%) from which inventor sex could be determined. Women submitted 7 of the 525 applications (1.3%). A total of 478 applications (86.8%) were submitted by a single inventor, 60 (10.9%) were submitted by 2 inventors, 11 (2.0%) were submitted by 3 inventors, and 2 (0.4%) were submitted by 4 inventors.

A total of 184 patent applications (33.4%) included a drawing of a human. Of these 184 applications, 128 (69.6%) included a drawing of a man, 14 (7.6%) included a drawing of a woman, and 45 (24.5%) included a drawing of an individual whose sex could not be determined.

Invention General Purpose

Of the inventions, 538 (97.6%) had a purpose of strengthening muscles, 20 (3.6%) had a purpose of measuring muscle strength, and 3 (0.6%) were neither for strengthening muscle nor measuring strength but were Indian clubs designed for shows and exhibitions.

Invention Type

Figure 5 displays the number of each type of invention. Mobile resistance units comprised 34.5% of the inventions and stationary resistance machines comprised 27.9%. Dumbbells comprised 16%, barbells comprised 6.7%, Indian clubs comprised 3.8%, and racks and benches comprised 8.0%. Table 3 displays the number of inventions that were barbells, dumbbells, and Indian clubs across decades.

Invention Features

Figure 6 displays the number of inventions that had certain design features. Of the inventions, 18.7% had a seat or bench, 15.1% had a cable-pulley design, 8.2% had a weight stack, 4.5% had a weight tray, 2.2% had a cam, and 5.3% had a performance display element. A total of 263 inventions (47.7%) included the capacity to adjust the structure of the invention in some way, whereas the other 288 inventions did not have this capacity or it was unclear whether they had this capacity. A total of 173 inventions (31.4%) included the capacity to adjust a structure to accommodate different body sizes, dimensions, or proportions, whereas the other 378 inventions did not have this capacity or it was unclear whether they had this capacity. Table 3 displays the number of inventions that included weight stacks and cams across decades.

Table 4
Types of resistances used in inventions of strength training equipment by decade.*

Decade	Bands	Body mass	Friction	Hydraulic	Isometric	Pneumatic	Springs	Weights, plates
1860–1869	0	0	0	0	0	0	0	3
1870–1879	0	0	0	0	0	0	0	0
1880–1889	0	0	0	0	0	0	0	4
1890–1899	0	0	0	0	0	0	0	6
1900–1909	4	0	0	0	0	0	3	18
1910–1919	0	0	0	0	0	0	0	7
1920–1929	0	1	0	0	0	0	4	10
1930–1939	0	0	1	0	0	0	1	5
1940–1949	0	1	0	1	0	0	1	7
1950–1959	1	2	3	2	0	0	1	10
1960–1969	4	11	14	5	9†	1	13	25
1970–1979	20†	29†	32†	13†	7	3†	41†	88†
Total	29	44	50	21	16	4	64	183

*Data for the following resistance types are not presented in the table: motor-driven, multiple types, others or n/a or unclear, or water.

†Decade in which that type of resistance was most frequently used in inventions of strength training equipment.

Resistance Type

Figure 7 displays the number of inventions that included certain types of resistance. The most common type of resistance was weights or plates (33.2%). Other notable resistance types included springs (11.6%), friction (9.1%), bands or other elastic elements (5.3%), and hydraulic (3.8%). A total of 65 inventions (11.8%) involved the use of multiple resistance types—e.g., sand or shot placed inside the bells of a light-weight dumbbell. A total of 4 inventions (0.7%) involved water as the only resistance, and 4 inventions (0.7%) involved sand or shot as the only resistance. A total of 397 inventions (72.1%) included the capacity to adjust the resistance, whereas 154 inventions (27.9%) did not include this capacity or it was unclear whether the invention included this capacity. Table 4 displays the number of inventions that included certain resistance types across decades.

Muscle Group

Figure 8 displays the number of inventions that were designed for certain body areas or muscle groups. A total of 3 inventions (0.6%) were designed to exercise the head or neck muscles, 134 (24.3%) the upper-body muscles only, 47 (8.5%) the lower-body muscles only, 14 (2.5%) the trunk muscles only, and 158 (28.9%) multiple major body areas, and 194 patent applications (31.8%) did not include mention of a target muscle group.

Exercise Number

A total of 115 inventions (20.9%) were designed for one exercise, whereas 248 inventions (45.0%) were designed for multiple exercises. For 187 patent applications (33.9%), the question of exercise number was either irrelevant or the inventor did not indicate whether the invention could be used for one exercise or multiple exercises.

Exercise Posture

Figure 9 displays the number of inventions designed for use in certain body postures. A total of 137 inventions (24.9%) were designed to be used in multiple postures. A total of 36 inventions (6.5%) were designed to be used while lying only, 36 (6.5%) were designed to be used while seated, and 80 (14.5%) were designed to be used while standing, and 262 patent applications (47.5%)

either did not include information on posture or the question was irrelevant to the invention.

Target Demographic Groups

Figure 10 displays the number of patent applications in which certain demographic groups were mentioned or implied. The most commonly mentioned group was athletes (i.e., sports performance) (15.4%), followed by patients (i.e., injury prevention or rehabilitation) (14.0%), youth (8.3%), and women (3.8%).

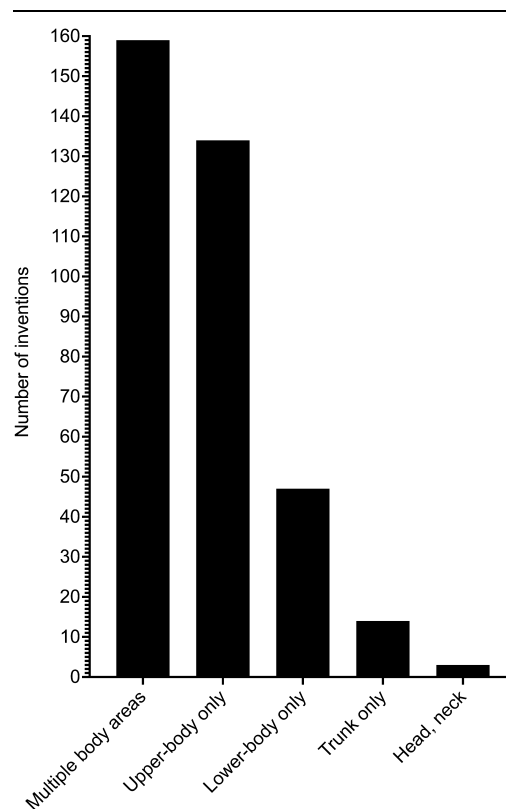


Figure 8. Number of inventions for strength training equipment before 1980 designed for certain body areas or muscle groups. A total of 194 patent applications did not mention targeted body areas and are not presented in the figure.

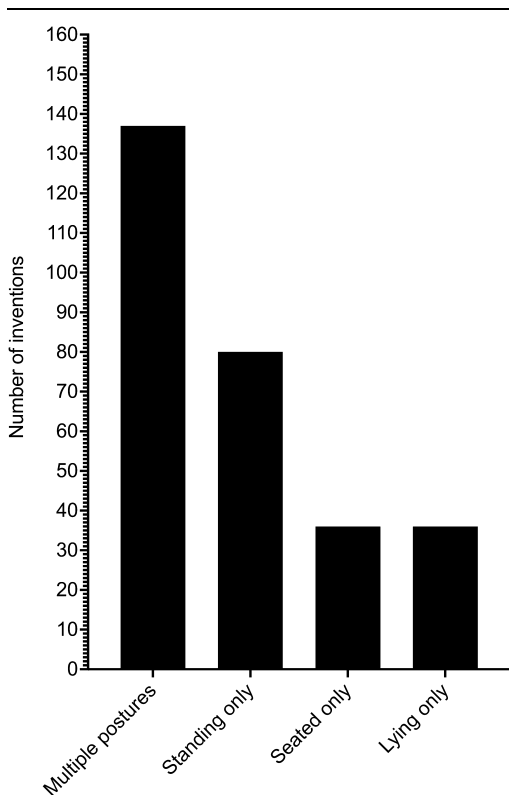


Figure 9. Number of inventions for strength training equipment before 1980 designed for use in certain body postures.

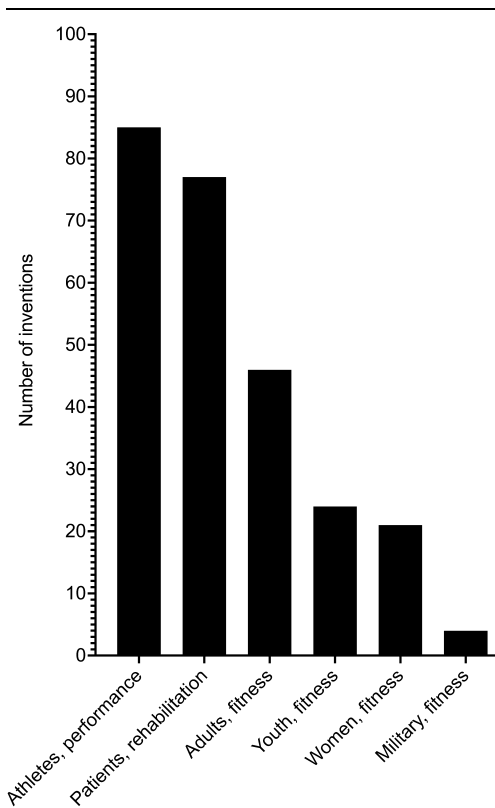


Figure 10. Number of inventions for strength training equipment before 1980 designed for certain demographic groups. These data reflect only explicit mention of these groups within patent applications.

Table 5 displays the number of patent applications in each decade that included mention of certain demographic groups.

Targeted Sports

Figure 11 displays the number of inventions designed for certain athletic or performance groups. The sport most targeted was golf (3.1%), followed by tennis (2.4%), skiing (1.6%), baseball (1.6%), arm wrestling (1.3%), and American football (1.3%). A total of 34 inventions (6.2%) involved the applications of resistance during a sport-specific skill (e.g., golf swing, tennis swing, and arm wrestling pin).

Objectives

Figure 12 displays the number of inventions designed to achieve certain objectives or technological advancements. The most common objective or advancement was adjustable resistance (37.4%). Other common objectives or advancements included inexpensive or reduced manufacturing costs (36.1%); simple to use or easy to operate (32.8%); compact design or easily stored (27.0%); multiple exercises can be performed with device (26.1%); improved safety or comfort (25.4%); more effective than existing devices (23.6%); portability (20.5%); adjustable size (15.8%); sturdiness, durability, or ruggedness (15.8%); home or office use (13.6%); and light weight (13.6%).

Discussion

In the current study, content analysis of patent applications was used to inform the history of strength training equipment. The

earliest patent applications identified were for dumbbells. The first application, titled “Dumb-bells” (US-28505-A), was filed by Daniel F. Savage. The patent for Savage’s invention was granted on May 29, 1860. Savage’s invention allowed the resistance of the dumbbell to be adjusted by connecting or disconnecting a series of “hemispherical or semispheroidal shells.” According to Savage: “The object of varying the weight of the balls is to graduate them to the muscular development of the person using them, for instance, when dumb-bells are first used by a person with soft muscles, they are required to be very light in order that the proper exercise may be taken without straining or injuring the muscular or even the ligamentous parts that are brought into active exertion, and by a constant exercise of this kind, the muscles soon begin to develop very rapidly and the weight of the bells should be gradually increased. At present, this can only be done by the purchase of new bells, but with my plan, the same bells may be graduated to the strength of different persons, either augmented or diminished with very little trouble.”

The next patents for dumbbells were granted in 1865. George B. Windship’s “Improvement in graduate dumb-bells” (US-46413-A) was patented on February 14, 1865. Windship’s invention was a dumbbell whose resistance could be adjusted using “removable disks or sections.” The disks had holes in their centers, and they were slid onto the ends of the dumbbell. Windship described the invention as “very simple in construction, cheap, strong, and quickly adjusted.” D.P. Butler’s “Improvements in dumb-bells” (US-48514) was filed on April 3, 1865, and patented approximately 3 months later on July 4, 1865. Similar to Savage’s dumbbell invention, the resistance of Butler’s dumbbell was adjusted using weighted shells that were added on top of each other.

Table 5
Number of times demographic groups were mentioned in patent applications by decade.

Decade	Athletes, performance	Patients, rehabilitation	Adults, fitness	Youth, fitness	Women, fitness	Military
1860–1869	0	0	0	0	0	0
1870–1879	1	0	0	0	0	0
1880–1889	1	0	0	0	0	0
1890–1899	0	0	0	0	0	0
1900–1909	1	0	1	1	0	0
1910–1919	0	1	1	2	0	0
1920–1929	1	1	1	0	0	1
1930–1939	1	0	2	0	0	0
1940–1949	1	4	1	1	0	1
1950–1959	0	8	1	1	0	0
1960–1969	12	14	12	6	6	0
1970–1979	66*	49*	27*	13*	15*	2*
Total	85	77	46	24	21	4

*Decade in which that demographic group was mentioned most frequently in patent applications.

As indicated in the following statement from Butler’s applications, Butler, like many other inventors, was attempting to help those of different strength and fitness levels: “[s]mall dumb-bells of a given weight are sometimes not so convenient to exercise with as larger ones of the same weight, though generally the reverse is the case; but this construction fully answers either requirement. For persons beginning to practice with dumb-bells, this arrangement enables them to begin with the lightest weight and gradually to increase the same by the addition from time to time, as may be desirable, of an extra shell, thus obviating the necessity of having a cumbersome set of different instruments.”

The number of applications submitted yearly between 1860 and 1960 never exceeded more than 6. A boom in submission occurred between 1961 and 1979, with 55 applications filed in 1979. However, at the same time submissions were increasing, processing times for patent approvals were becoming longer. Before the 1930s, patents were typically granted within 1.5 years of the date they were filed. After 1940, patents were typically granted within 2–3 years.

Certain types and features of strength training equipment evolved from the 1860s to the 1970s. Inventions for dumbbells and Indian clubs were common in the 1800s and early 1900s, but they became less common over time. Today, Indian clubs are almost entirely defunct (20). Nevertheless, as patent applications for certain equipment declined with time, new equipment emerged. For example, in the 1960s and 1970s, a number of weight stack machines and cam-based machines were patented.

General trends associated with inventions for strength training equipment between 1860s and 1970s warrant mention. First, 98.7% of inventions for strength training equipment were created by men. The most prolific of these inventors was Lloyd J. Lambert, Jr, who between 1977 and 1979 submitted 10 patent applications, mostly for weight stack machines. Other notable inventors included Thomas DeLorme (US-3323366-A), who developed a system of progressive resistance exercise (21); Robert Hoffman (US-3207511-A), who owned York Barbell Company, coached the U.S. Olympic weightlifting team, and founded *Strength & Health* magazine (2); Arthur Jones (US-3858873-A and US-3998454-A), who founded Nautilus and MedX; and Jack LaLanne (US-3438627-A, US-3647209-A, and US-3752473-A), who was a fitness guru. The finding of a substantial sex difference in patent submissions for strength training equipment is consistent with the findings from Frietsch et al. (4), who reported men

submit more than 85% of all patent applications across various scientific domains and in a number of countries.

Second, inventions for strength training equipment often shared core objectives or purposes. These objectives and purposes can be memorized using the mnemonic device CHAPS MANLINESS (Table 6). The men who invented these devices were attempting to make strength training more affordable, more accessible, more convenient, more personalized, more effective, and safer. Resistance was made adjustable to accommodate individuals with different strength levels; sizes and positions of machine elements were adjustable to accommodate individuals with different body sizes and dimensions, etc. Billy D. Madden, in patent application US-

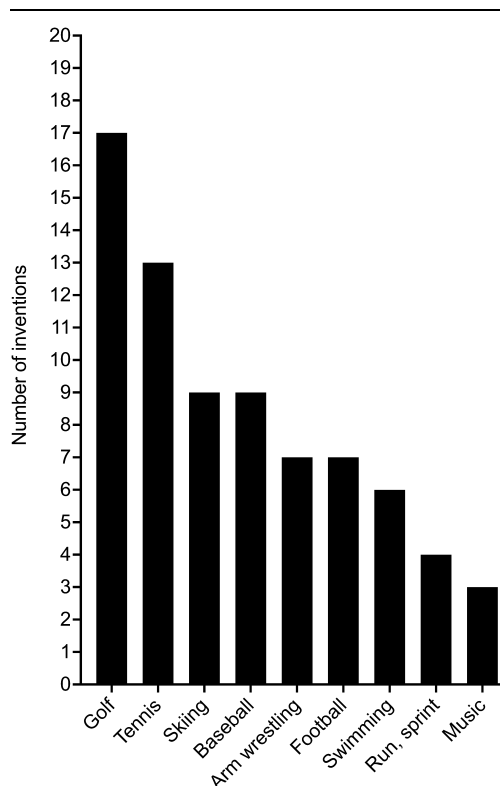


Figure 11. Number of inventions for strength training equipment before 1980 designed for certain athletic or performance groups.

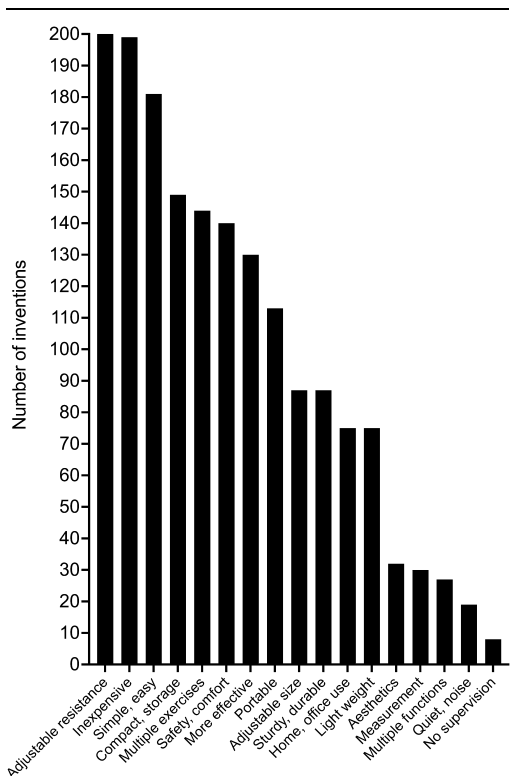


Figure 12. Number of inventions for strength training equipment before 1980 designed to achieve certain objectives or technological advancements.

3573866-A, expressed a number of these core objectives: “An object of this invention is to provide an exerciser which is adaptable for different size people without any adjustment. Other objects are to achieve the above with a device that is sturdy, compact, lightweight, durable, simple, safe, versatile, efficient, and reliable, yet inexpensive and easy to manufacture, transport, operate, and maintain. Further objects are to achieve the above with a method that is lightweight, efficient, rapid, safe, and inexpensive, and does not require skilled people to install, adjust, operate, and maintain.”

Third, most inventions were designed only for upper-body muscles or a combination of upper-body and lower-body muscles or trunk muscles and upper-body or lower-body muscles. Fourth, inventions were designed to accommodate multiple exercises more so than just one exercise. Fifth, inventions were more often designed for use in multiple body postures or in a standing posture than in lying or seated postures.

Specific trends and particular inventions for strength training equipment between 1860s and 1970s also warrant mention. First, with dumbbells, a somewhat common idea was that exercisers should perform a second task while lifting the dumbbell. For example, multiple dumbbell inventions included a spring resistance grip that required the exerciser to squeeze springs while lifting the dumbbell (e.g., US-1229658-A, US-630741-A, US-654097-A, US-786318-A, US-1119169-A, US-1130620-A, US-1395313-A, and US-881438-A). In addition, some dumbbell inventions included application of an electric shock to the exerciser while they lifted the dumbbell (US-1583261-A, US-689406-A, US-873066-A, US-310733-A, and US-590050-A).

Second, some inventions had purposes other than strength exercise and strength measurement. Some inventions doubled as furniture. For example, one dumbbell was also a book end (US-3971556-A). Another example was a table, whose legs could be used as

Table 6
Mnemonic device to remember basic characteristics of inventions for strength training equipment (CHAPS MANLINESS).

C	Compact	Device is compact, small, and can be easily stored.
H	Home use	Device can be used at home or in office.
A	Adjustability	Device resistance and structure are adjustable.
P	Portable	Device is portable.
S	Simple	Device is simple to use and easy to operate.
M	Multiplicity	Device can be used for multiple exercises and functions.
A	Aesthetics	Device is aesthetically pleasing to look at.
N	Noiseless	Device is quiet and does not involve loud clanging.
L	Light weight	Device is light weight.
I	Inexpensive	Device is low-cost and inexpensive to manufacture.
N	No supervision	Device can be used without supervision.
E	Effectiveness	Device is more effective for achieving outcome than previous devices.
S	Safety	Device improves exercise safety and comfort.
S	Sturdiness	Device is sturdy, durable, or rugged.

Acronym was created at <https://ingesanagram.appspot.com>. The acronym SPINAL CHESSMAN can also be used.

handles for push-ups (US-4222559-A). Another was a spring-resistance device that doubled as a cushioned seat (US-3893667-A). Other strength equipment inventions doubled as massagers (US-742393-A, US-1254974-A), toys or games (US-1123570-A, US-3102280-A, US-3593994-A), and coin banks (US-4121826-A).

Third, inventions that involved application of resistance during sports or performance skills were not uncommon. Thirty-four inventions involved application of resistance during golf swings, tennis swings, arm wrestling pins, swimming, skiing, or playing a musical instrument. The notion that application of a resistance to a sport-specific movement would improve performance on the sport skill was also a topic of research over the same period (11).

Fourth, although almost all resistance types were most common in the 1970s, because of the boom in inventions during this decade, not all resistance types exhibited the same trend in use over time. For example, when compared with other resistance types, the use of weights or plates was relatively stable between the 1860s and 1970s (Table 4). In addition, inventions that involved isometrics against immovable resistance were just as common in the 1960s as in the 1970s. This corresponds to the pique in interest in isometrics in research and practice in the 1950s and 1960s (3,11,23). In addition, regarding isokinetic muscle contractions, James Perrine submitted a patent application titled “Isokinetic exercise process and apparatus” in 1965 (US-3465592-A). In the application, Perrine introduced the idea of isokinetics. This idea was quickly adopted for research purposes in the late 1960s (11). Perrine’s patent was later granted in 1969.

Fifth, cam-based resistance machines were introduced in the 1970s, with 12 applications submitted in that decade. Both Arthur J. Jones and Lloyd J. Lambert Sr. submitted patent applications for cam-based machines in 1973. Jones submitted his application on May 15, 1973 (US-3858873-A). Lambert Sr. submitted his application on July 12, 1973 (US-3912261-A). Jones submitted another application for a cam-based device in 1974 (US-3998454-A), and Lloyd J. Lambert Jr. submitted 7 applications for cam-based devices between 1977 and 1979 (Table 2).

The current content analysis was not without limitations. First, the patent search should not be considered exhaustive. The keyword searches performed in Google Patents might not have identified all patent applications for strength training equipment filed before 1980, and no attempt was made to identify patent applications cited in the identified applications. Second, no

judgment was made to the credibility of the claims made by the inventors. Some devices might not have been able to achieve the objectives desired by the inventor. Third, no attempt was made to trace the successes or failures of the inventions in the marketplace. Finally, little attempt was made to put the results from the current study into a broader social or cultural context. Such attempts can be made in future qualitative accounts of the history of strength training. The list of applications analyzed (12) can be used to aid such future efforts.

Practical Applications

A variety of strength training equipment has been invented since the 1860s. Thus, strength and conditioning coaches and fitness professional have a variety of equipment to choose from when deciding which equipment to purchase or to prescribe. Debate about what type of equipment to prescribe in training programs often centers around the idea of optimal physiological effectiveness (5,13,16). In studies on free-weight equipment versus stationary machines, researchers have often aimed to determine which equipment leads to the greatest improvements in muscle strength or other performance outcomes (5,6,14,27). However, improvements in muscle strength occur with most equipment—free weights, stationary machines, and elastic bands (1,6,14,25,27). Thus, the decision to use one type of strength training equipment over another can also depend on factors such as space, budget, personal preferences, etc. Inventors have always been aware of these factors, and each strength training device will offer certain advantages and disadvantages. The coach and fitness professional thus must consider the balance of these advantages and disadvantages when deciding to purchase or prescribe strength training equipment. Finally, the current analysis led to the identification of basic purposes of inventions for strength training equipment (Table 6). An understanding of these basic purposes by exercise science students, strength and conditioning coaches, and fitness professionals might lead to further innovations in strength training equipment, which might then make strength training more affordable, accessible, convenient, personalized, effective, enjoyable, and safer. Such innovations might help to improve participation in strength training and adherence to it. Currently, there is a need for improved strength training participation and adherence because approximately 70% of populations of most countries do not meet recommended guidelines for muscle-strengthening activities (10).

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