

Developing the Next "Wow" Fitness Product

by

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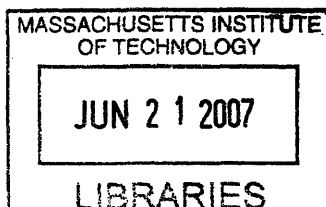
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ABSTRACT

The fitness industry has not seen a commercially successful revolution since the elliptical trainer in the mid 1990s. Newer products such as the Cybex Arc Trainer are vying to replicate this success, but are only slowly gaining acceptance. Most companies that have tried to succeed with unique products or heavy telemarketing, have failed in leaving any lasting or notable mark. In an attempt to do what others have failed in doing, the goal of this project was to develop the next revolutionary product in the industry. In the footsteps of the elliptical trainer and Bowflex, the aim is to design a brand new fitness product to create industry buzz and become a household name. The work done has gone through the usual design process, beginning with extensive research and continuing to problem selection, solution brainstorming, quantity conceptualization, quality narrowing, and concept development. After understanding the general biological happenings behind fitness, recognizing the intended consumer, analyzing needs and trends within the industry, and researching other recently successful technologies in other industries, solid concepts were developed that were narrowed down to the final concept of sensor gloves capable of intelligently recognizing exercises, sets, and repetitions during a weightlifting exercise session, and compiling the information into an organized and user friendly software presentation.

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Introduction

The project's main goal from the beginning has been to develop the next "wow" fitness product. With such a broad goal, it provides plenty of areas in which to operate and few limitations. The fitness industry is a large industry, divided into cardio, strength, and specialty equipment, with the last subgroup serving as a lump category for all products related to fitness that do not fit within the other two subgroups. The first two have concrete defining products, the cardio machine is defined by the treadmill and elliptical trainers while the thought of strength equipment sparks images of the Bowflex multigym system, but the specialty subgroup is not clearly defined, encompassing everything from Pilate equipment, to gym accessories, to gimmicky fitness equipment. With this, some may be hesitant and deem having such a vast initial need/problem statement as dangerous because of its lack of focus and requirement of expansive research that will not all be directly relevant to the final product. Because of the lofty goal of this project, though, such expansiveness is necessary and the designers should understand all the aspects of the industry as well as successful role-model products in other industries. In note to the latter, the customers and consumers are not just purchasing fitness equipment, so it is worth understanding their other interests and wants and incorporating these general trends into products that aspire to also be purchased by said individuals.

With that, these targeted end-users and consumers are out of shape individuals looking for home fitness equipment at a value-price point and getting all their wants at a reasonable price. This does not mean the consumer is cheap, however, because they are willing to pay extra for quality, not to the extent of upgrading to the next level, but

willing to pay more for product X if it provides extra features, better aesthetics, more convenience, or a combination thereof, than product Y.

Therefore, even with our limited time, to properly conceptualize such a “wow” fitness product, it is essential to fully understand the industry and then fully undergo the engineering design process, getting acquainted with all the relevant information as well as previous and current industry technologies, trends, successes, and failures, to gain a firm grasp on what has already been done, what needs to be re-looked at, and what issues still need to be addressed.

Following this, the project must continue systematically, developing the product by generating ideas, conceptually developing the promising ideas, and then making tangible mockups and prototypes with which to conduct testing. The results of the testing will then lead to further iterations that will coalesce into the final mass-market “wow” success that was intended from the beginning.

Design Process (General)

The design process can be viewed as a large section of a pipeline. Initially you have a need or problem entering the pipeline. Soon after entering, it encounters a goal or idea, which progresses with background, market, industry, and technology research. The idea must then be conceptualized into possible solutions in quantity. These possible solutions are then narrowed via criteria, limiting them to the most promising and viable options which then continue on to be developed and iterated into mock-ups addressing major issues and then prototypes showing more complete realizations of the solution. Once a promising prototype is developed it is used to do testing, both classic (experimental) and applied (with a user), to gauge quality, interest, and identify subtle and egregious problems. The prototype is refined according to test results and more testing is conducted until the prototype is iterated into a satisfactory product. Mass manufacturing must then be made efficient for the product and this finished design exits the pipeline. Constant evaluation and improvement should then be applied to the product addressing any issues or improvements by returning to an abbreviated design pipeline. In reality, not all designs will make it out of the pipeline. The product may at any point be halted by an insurmountable barrier, technological or financial, and be held there until a future time or indefinitely.

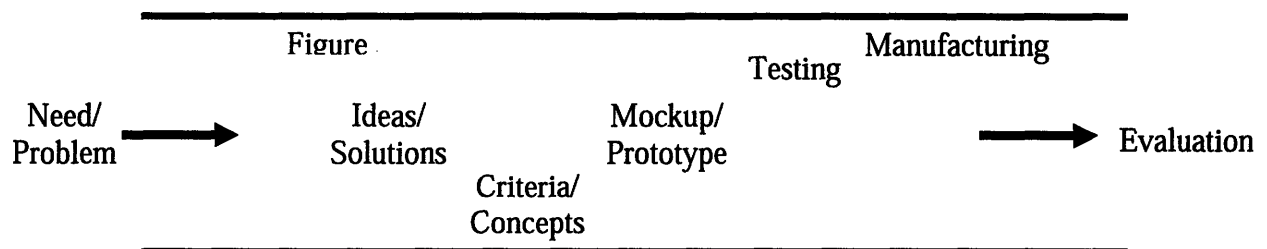


Figure 1: Product Design Pipeline

- Need/Problem

The initial step of the design process is problem identification. A problem often begins as a vague jumble in the designer's mind, sparked by a human need. The problem must, however, be made specific and well defined so that it can be readily understood. This is accomplished by meditating on and contemplating the underlying human need that sparked the vague problem and elaborating on this need. The designer must first ensure that the posed need is the real need and not an apparent need or current solution; they must ensure that they are addressing the cause and not the symptom. Amateur designers often get caught up in criticizing and improving current solutions rather than addressing the more fundamental problem, which always leads to limited improvement and stifled ingenuity. Once the need is made concrete, to ensure specificity, the need/problem statement should be stated as a gap, comparing how things are today to how they should be. With the problem well stated, research follows.

As a separate note, when doing open-ended problem solving, it is beneficial that "raw ideas be developed in tandem with need/problem statements using one to help establish the other." (Reference 14) This can be done either top down with need/problem statements leading to ideas that fulfill them or bottom up by categorizing ideas into a need/problem statement.

-Research

Before addressing any problem it is important to fully understand the problem and have a strong fundamental base and grasp of the situations surrounding it. This is done by researching. Within product design, research comes in four

distinct variants: background, market, industry, and technology. Without being acquainted with the four areas, the innovator is limited in understanding and viewpoint, and will not understand the specific musts and must-nots that constrain the problem. So in research it is important to understand the what and why of the culture, who the customers and consumers are, who the people are working in the field and why they do what they do, and what is currently available for addressing the issue and similar issues, as well as what other pertinent technologies have succeeded or failed in other industries.

Firstly, often as designer, one is called to work within an unfamiliar area. The first step in addressing an unfamiliar problem is to acquaint oneself with the terms, mindset, and culture of the area. Even if the topic is familiar territory to the designer, however, it is always worth doing even cursory background research. One cannot be a credible designer if not well versed and up to date in the surrounding environment of the problem. The designer should be submerged in the culture, so not as simply doing scholastic “outside” research but also hands on “inside” research. As an example, in addressing the problem of humanitarian demining it is worthwhile to spend time doing just that, demining, along with understanding the surrounding issues such as why accidents happen, which countries are affected, where these countries are located, how long it has been a problem, who are the perpetrators laying the mines, how landmines work, how long they last, how they are financed, etc. With this mix of knowledge and experience based understanding, a designer is in a better position to address the issue.

Secondly, one would be monetarily unwise, to not also understand the market in which the issue is being addressed. The customer has certain wants and constraints that he places on solutions and will not be open to products that are not within these boundaries. There are two subgroups within the market: The customer who is the primary and direct purchaser of the equipment and the consumer who is the end-user. It is possible for the two to be the same, but more often than not they are separate entities. Continuing with the humanitarian demining example, the customers are the non-government organizations, and governments employing and deploying personnel to demine, while the consumer are the actual field workers, mainly deminers, but also supervisors, dog handlers, explosive ordnance disposal (EOD) specialists, medical personnel, and others directly involved in the demining effort. As a designer, the consumer is often more important to understand and specifically determine than the customer, because often the customer has more secondary needs that can be addressed much latter in the design process when the product is virtually complete. Too narrow of a definition of the consumer, however, and the designer limits brainstorming and solution generation, while too broad of a consumer, leads to impertinent solutions. An in between balance is required and can usually answer the question, "Does the solution address something that the individual encounters on a day to day basis?"

Thirdly, understanding the industry is a necessary part of research. This is different than developing a general understanding for the environment of the problem in that you are looking at the specific companies, manufacturers, professionals, and organizations that are working to improve the problem and all

those similar enough to fall within a broad encompassing need or consumer.

Though there is some overlap, especially with the background, one can look at it as that while the culture is a general mentality, the consumer is an individual with wants and needs, and the industry are the individuals looking to fulfill the consumer's wants and needs. Once again continuing with humanitarian demining, the culture surrounding those affected by landmines, is different than the industry culture of those who develop the manual equipment (prodders, metal detectors, detonation devices, flails, etc.) and personal protective equipment (visors, aprons, bomb blankets, blast shields, etc.).

Finally, researching technologies refers to understanding products in the industry that have been both successful and failed in addressing the same and similar needs and problems, as well as those that have succeeded or failed in other pertinent industries. Developing new concepts and solutions without understanding the what, how, and why of current offerings is inefficient and naïve, resulting in similar solutions that retrace already treaded steps. Many good ideas have already been thought up and conceptualized and a designer will save time by finding them and learning from them.

-Ideas/Solutions

Idea and solution generation is accomplished in various ways including: spontaneous idea generation, systematic idea generation, clear statement analysis, direct attempt, and idea association and collision. Traditionally, though, this has been achieved via a process known as brainstorming, "a creativity technique used to generate a large

number of ideas for the solution to a problem.” (Reference 12) Originally developed by Alex Faickney Osborn in the 1930s to increase productivity and creativity, there are four self-explanatory rules to ensure effectiveness in the brainstorming process: focus on quantity, no criticism, unusual ideas are welcome, and combine and improve ideas. Along with these steadfast rules other recommendations include: maintaining a group no larger than ten, ensuring that everyone understands the problem and its specifics, providing a relaxed environment, allotting for both individual and group brainstorming, recording all ideas presented, and prescribing a mostly-rigid time limit. Brainstorming sessions are notorious for going off topic and overtime, and have been criticized because extroverted individuals usually takeover the session and squelch others, resulting in an inefficient method of employing individual resources. Because of this, the facilitator should serve as a moderator and regulator, actively working to prevent the known negatives from happening and ensuring that the positives do. (Reference 12)

Brainstorming should generate solutions that range from obvious to obscure, sophisticated to simplistic, realistic to visionary. As stated by the first rule of brainstorming, the initial need in solution generation is rich, varied quantity often approaching the triple digits. Following the second rule, ideas at this stage in the design process should not be judged, censored, or discarded. If an idea beckons to be dismissed due to its impracticality or silliness, one should think along the same lines and conceptualize a similar idea that does not do so and contributes rather than detracts. “No idea should be initially discarded because even if it itself turns out to be ridiculous or impractical, it may spark thinking in a varied way that provides another better solution.” (Reference 14)

Also at this stage, ideas may be “complete ideas for a whole product that addresses an opportunity fairly completely or idea fragments for a part of a whole product that meets a sub-opportunity or solves a sub-problem that must be further developed to describe a whole product.” (Reference 14) Idea fragments are especially good for mixing and matching to spark new ways of thinking on complete solutions.

It is important to note that there are other methods of creative thinking and idea generation available. Most notably is the concept of brainwriting, where individuals in a group initially independently brainstorm on sheets of paper and after an allotted amount of time they pass their work to the next person who uses the ideas to trigger more ideas. The most common setup for this is called BrainWriting 6-3-5 where brainwriting is done with six people per group, who generate three ideas per rotation, in five minute rotations. Another method is the acrostic SCAMPER, where each letter suggests a step that the designer should undergo when looking to improve a design: Substitute, Combine, Adapt, Modify/Magnify/Minimize, Put to Different Use, Eliminate, Reverse/Reciprocate. All these other methods, accomplish the same final goal as brainstorming, but are simply less well known and provide their own set of advantages and disadvantages. (For more creative thinking resources, refer to Appendix E)

-Criteria/Concepts

Once quantity has been established, ideas must be narrowed to keep the quality ones. This is done by applying design criteria to all solutions in a spreadsheet matrix. Specifically, criteria differ from problem to problem, as they are “the specifications design solutions must meet and attributes which solutions must possess to be considered

successful.” (Reference 13) Criteria usually address the areas of: design, development, material, construction, production, manufacturing, industrial design (aesthetics), sales, transport, safety, environmental effects, disposal, designer, and user. Gut feeling and personal interest, though they should not be the driving force, are also legitimate criteria for most projects. Continuing the example, if addressing the issue of improving personal protective equipment in humanitarian demining, one would need to rank various ideas against (among others): weight, weight distribution, ventilation, cost, and integration with existing standard operating procedures. Inevitably certain criteria will be intrinsically more important and this can be addressed by adding more value to such criteria (weighed average), but it is stressed that this is often unnecessary.

In doing the criteria spreadsheet, there must be an established base. If a solution exists, this will be the base; if various solutions exist, one should be arbitrarily chosen; and if there is no existing solution, one of the proposed solutions should be arbitrarily chosen as the base. It is important to note, that more expansive need/problem statements will have solutions that will require a varying base, each comparing itself to the current epitomical product. This, however, should also be viewed as a hint that the need/problem statement may be too large and require narrowing. Criteria within the matrix should be phrased in a quantitative manner, so as to be evaluated in a binary (yes/no, +/-), standard (+/-/0), positively progressive (0 to 5) scale, or positive-negative progressive (-5 to 5) scale. When using negatives, negatives should always be bad and positives should always be good. As examples, rather than a negative for cost meaning the product has decreased in cost, it should mean that the cost will change in an unfavorable manner (namely cost increasing). The same is true for size, weight, and other criteria where the

value literally changes. A criteria sheet that would be used in relation to improving personal protective equipment in humanitarian demining is provided below:

	Current	Basic	Basic T	Long Visor	Helmet	Scarf	Shield	Back	Shoulder
Weight	0	0	0	0	-1	-1	-2	-2	-1
Weight Dist	0	1	1	-1	1	-1	2	2	1
Neck Gap	0	1	2	1	2	1	2	1	1
Scratching	0	1	1	0	1	0	2	1	1
Fogging	0	1	1	0	-1	0	2	0	0
Ventilation	0	0	0	0	-1	-1	2	0	1
Cost	0	1	0	0	-1	-1	-2	-2	-1
Comm	0	2	1	0	-2	-1	-2	-1	1
Existing SOP/PPE	0	-1	-1	0	0	-1	-2	-2	0
Total	0			0	-2	-5	2	-3	

Figure 2: Humanitarian Demining Criteria Sheet.
Base is current apron + visor solution

With possible solutions narrowed to probable solutions via the criteria sheet, the ideas must be further developed by conceptually elaborating on features and design. Detailed conceptualization should be accompanied with various views of detailed drawings and CAD drawings. Along with these it becomes important at this step to begin consideration of the “difficult questions” that are still left unanswered in relation to the problem and, equally important, the idea. The former should already be known, while the latter questions in reference to each idea should “get at the essence of the concept.” What are the main issues? A few issues surrounding an idea should be self-evident and arise immediately, while many of the more fundamental and important issues will not arise without extensive thinking. Because of this latter point, it is important to give thought to these questions and not simply assume that since a brief list of difficult questions are immediately attained, that there are not more. Once the questions are identified, they

must be addressed which must be done promptly taking into account that this will require time, research, and resources. Problems will not resolve themselves and early conceptual-loading will reduce problem compounding further down the pipeline.

-Mockup/Prototype

With a detailed idea of what needs to be done, the next step is to begin making sketch models and mockups. A sketch model should provide proof of concept made of cheap, easy to shape materials. Cardboard and foam are popular choices, but by no means the only options. The idea behind sketch modeling is mainly to use inexpensive, easy to form materials. A mockup, on the other hand, should address the large issues of the product using more accurate, yet not necessarily identical, materials to the ones which are proposed for the actual product. Often various mockups are made each addressing an individual issue, whether a specific mechanism, aesthetics, etc. and the feasibility of each. The tangibility of these is key, because it will allow concrete visualization which will lead to discovering issues that were not immediately seen when conceptualizing. The mockups especially will go through iterations as issues will arise and testing will require adjustments that must then also be tested.

The conglomeration of mockups culminates in the alpha prototype, the first fully functional product. Testing will inevitably also lead to prototype iteration, addressing most of the flaws before progressing to manufacturing considerations. Even if not perfect, it is often beneficial to have multiple copies of a prototype so that some can be dedicated to testing while others can be used as presentation and marketing tools.

-Testing

Testing should occur early and often, as it is the integral part of the later stages of the design pipeline. It should begin once there is a tangible sketch model and continue through mockups, prototypes, and even manufacturing. A product is rarely perfected, therefore improvement should be sought constantly. Testing should be both experimental and practical, conducted in the lab and in the field, with the innovators posing as consumers and also actual consumers. The former should be done to test material properties, mechanisms, and operations under ideal and simulated conditions, while the latter is done mainly to gauge durability, implementation, consumer interest, and to identify the subtle problems of the product. This last point is highly important and often overlooked, but minor problems will arise ranging from pinch points to chaffing points to improper product employment to anything else, and these issues must first be identified to then be addressed. It is important to note that these small issues are often what determines the level of success of a product and are therefore essential to eliminate to produce a top-end quality product. To ensure that all these issues are discovered before going to market and mass manufacturing, it is necessary to do extensive (breadth and amount) and varied (type and consumer) testing.

-Manufacturing

Sketch models, mockups, and prototypes are made by the most convenient or readily available methods, while the manufacturing process must be systematically optimized and made efficient for reducing cost and ensuring consistent quality within a mass production setting. This requires understanding available methods of creating and producing certain parts and handling different material types. Because of this, and

opposed to popular belief, there is no correlation between prototyping cost and manufacturing cost, as each is made entirely different, in different amounts, with different purposes in mind. Production, quantity and purpose are therefore the major differences between the two, with the low quantity of the prototype allowing for production via expensive though convenient methods and allowing for post production modifications, while the intended use of a prototype (testing and display rather than profit and consumer use), creates no sense of finality and a lesser stress on quality and consistency. The finality and expansiveness of mass production, however, makes it impractical for flawed design requiring post production modifications, while the want of creating maximum marginal profits requires manufacturing at minimal cost via the most appropriate and economical methods available.

-Evaluation

With a product on the market, it becomes necessary to evaluate its level of success and more importantly make observations on why this is such. Customer acceptance, timing, press coverage, marketing level, perceptions, and short comings are some of the various categorizes that must be observed. If the product is doing well in a category this should be noted and if it is not, this should be realized and changed.

-Other Considerations

When going through the design process, there are considerations that should be made by a designer to reduce late-stage iteration (a list that looks very similar to criteria considerations), namely manufacturing, sales, purchasing, material, cost, pricing,

transport, safety, disposal, environmental effects, and user-interface. Can the product be produced with current facilities to ensure its success? Does the customer actually want the product? Is there a demand for the product? Are parts necessary for construction readily available? Can the product be constructed within the proper cost structure level? What is the product's initial intended retail price? Is the product properly sized for transporting and shipping? Will the product need to be shipped in parts and be put together? Can construction instructions be well conveyed in a user's manual? Is the product safe? Is the product easily disposable? Does the product require any sort of special recycling or disposal? Is the product environmentally friendly? Is the product easy to use? If there is a learning curve is the product properly documented?

Specifically addressing the marketing question, when marketing a product it is important to emphasize to the customers and consumers the benefits of the product rather than the features. "People don't want a drill, they want a quarter inch hole." (Theodore Levitt, Harvard Business School marketing professor). Customers do not care what a machine can do, but rather what it can do as compared to current products and in turn how it will sell. Consumers do not care about what a machine can do, but rather what a machine can do for them. This can be accomplished by varying wording; not stating, "The product will do this," but rather, "The product will do this for you" or "The product can do this to help you accomplish this".

As another consideration stated earlier, certain products will be stopped within the design pipeline by insurmountable obstacles, ranging from lack of technological capability, to improper market timing, to world events, to financial issues. Along these lines, not every product will undergo the same time of production. Depending on group

ability and experience as well as the specific project, general timing will vary as well as time spent in the specific regions of the pipeline. Seeking to improve an existing product will have a clearer problem statement and require less time in seeking customer acceptance, while needing more idea generation time. Developing a brand new product to address an untouched need will require more time solidifying the problem statement, less time developing solutions, and extensive time prototyping solutions and conducting testing.

Product design is a sensitive art, with many subtleties and the product's success is dependent on quality and effort throughout the design process. It is therefore important to not get complacent, lazy, or apathetic late in the design pipeline as the novelty of the concept wears thin, deadlines draw near, and challenging issues arise. A low level of dedication is directly correlated to prematurely dooming a project. It is the small things that make or break products for the consumer, and it is the small things that will get ignored when the above occurs.

To prevent the above, it is essential that when a product enters the design pipeline that one not only "push" it from the designer's side, but to also to have a customer, consumer, or well respected industry representative "pull" the product from downstream. This "push-pull" system assists in keeping the development of a product on track conceptually and in terms of time. It creates a secondary motivation for the realization of the product. Along with motivation, the downstream "pulling" individual or group variedly contributes to the project. The individuals may simply serve as evaluators, being periodically updated by the designer and providing feedback, or may serve as testers using mock-ups and prototypes as they become available, or may actively be working to

develop the product by serving as a industry advisor to the design team. No matter at what level these individuals serve, they should be identified early on to provide constant direction and purpose. (Reference 14)

Research

In developing any product there are four areas of research that must be addressed to ensure that the designers have a practical understanding of the information surrounding the problem that is to be solved: Background, market, industry, and current solutions.

Background refers to the underlying reason for the existence of the industry as well as the cultural information surrounding the industry, and is essential for gaining credibility. A designer would be personally naïve and socially unaccepted if they do not have an understanding of a problem's underlying background. Without this the designer cannot be relied on to develop an effective, plausible, and culturally sensitive solution. As examples, two popular consumer electronics these days are mp3 players and cell phones. Understanding the background surrounding mp3 player means having a general understanding of music distribution, music listening, and music making; on the other hand, for the cell phone one should seek to understand call etiquette, call making, and the purpose behind phone calls (personal and business). Specifically for this project and the fitness equipment industry, this means understanding the fitness components required for one to become more physically fit and the general process of muscle development, energy expenditure, and the benefits of physical exercise. Cultural terminology is also essential, necessary for connecting to the en-users utilizing the products.

The market is both the customer and consumer who will be purchasing and using the product. The customer is usually the company, distributor, wholesale store, or retail store, etc. that will be directly purchasing the product, while the consumer is the end-user who will actually use the product. The latter is significantly more important and should be the focus when researching and developing, but to be profitable products must be sold

and the needs of the customer cannot be fully ignored or sales will not occur. End users often fit into broad categories based on buying power, interests, etc. which must be taken into account when marketing a product.

The industry must also be understood. General norms, past occurrences of importance, past successes and failures, past legislations, current endeavors, general trends, essential product features, associated stigmas and stereotypes, competitors, and leaders all require to be understood and researched. "Industry" terminology is also important to understand. Examples of this for the fitness industry include: Bowflex, power bars, kettle bells, arc trainers, etc

Current solutions research includes both products and pertinent technologies that address the problem and similar issues. Seeing how a problem is currently solved can provide insight into the problem and provide one way of viewing possible solutions. Similar benefit comes from analyzing similar problems. Further, it is important to recognize successes in other fields (related and not) and understand how and why they are successes. These products have obviously done something right, whether being a genuinely good product or properly appealing to a specific consumer type and this advantage that they have employed may at some level, be transferable to one's own design.

Each part of research is necessary piece of the whole and undermining any of these four sections, unduly hinders product development early on. It is important that the research be done thoroughly initially but then progressively continued throughout the design process. Though the background, market, and industry will not change in the microscale, current solutions are every being created, implemented, and brought to

market, requiring that one stay up to date on such matters. It is stressed again, that an innovator can proceed without doing proper research, but without having a well grounded foundation of understanding, the future of the project promises to run into unneeded problems that have already been solved and promises to lose focus.

Fitness

Wide spread interest in physical fitness has been sparked in recent times by increases in overweight and obesity through out the United States and the developed world. These problems are compounded by leading to high blood pressure, high cholesterol, joint problems, bone problems, and liver and gall bladder diseases among others. The World Health Organizations states that over one billion adults are overweight. In the USA, the Centers for Disease Control predicts that it costs the nation alone \$100 billion per year. The main cause of these problems is the increased consumption of energy-dense foods and decrease in physical fitness. Fitness is therefore not only of commercial interest but a necessity for the well-being of the nation. (Reference 1 & 2)

Before addressing how fitness is improved, it is important to have a rough idea of how the body produces energy because fitness revolves around the body's expenditure of energy. This expenditure occurs both aerobically and anaerobically, depending on an activity's energy level requirements and duration. The former is defined as energy produced in the presence of oxygen, while the latter is energy that is produced without the need of oxygen, and each result in powering biochemical cellular processes in the body by creating ATP, adenosine triphosphate. To allow for activity and muscular contraction, the body creates energy via three methods: ATP-PC (Adenosine

triphosphate-phosphate creatine), Glycolysis, and the Krebs's/Citric Acid/Tricarboxylic Acid Cycle. In muscles, the phosphate-creatine compound assists in ATP formation by breaking down and combining with ADP anaerobically. It is the fastest method to produce ATP and also very rapidly expended. Glycolysis is also anaerobic and produces two ATP molecules plus pyruvic acid. The pyruvic acid in turn breaks down into lactate and hydrogen ions, with the latter release being the culprit of muscle fatigue. As opposed to the wide belief that soreness is due to the lactate, it is the H⁺ ions that acidify cell bodies by not being reduced quickly enough, an occurrence that begins at the lactate threshold. Finally, the third method of ATP energy synthesis, the Krebs's Cycle, follows glycolysis and is aerobic, producing thirty-four ATP molecules per cycle.

In general anerobic energy is associated with power, high intensity, and short duration, while aerobic energy is associated with endurance, lower intensity, and prolonged exercise durations. In relation to fitness, it is also important to understand when and how long these processes occur. The following graph shows a rough breakdown of the body's recruitment of these various energy processes over time:

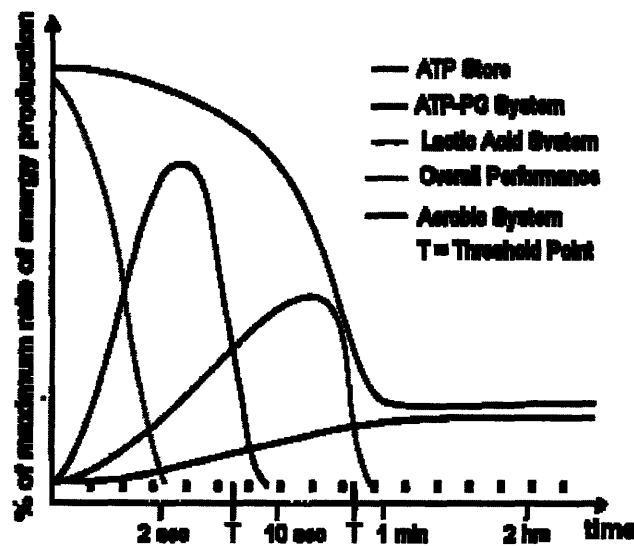


Figure 3: Energy synthesis recruitment in relation to exertion time
(Reference 15)

Another high level fitness concept to understand is muscular tissue development. Muscles are made up of a mixture of fast twitch and slow twitch fibers. The former are responsible for developing greater force and contract faster with greater anaerobic capacity, while the latter develop force slowly and can maintain contractions longer with greater aerobic capacities. Research shows that resistance training increases the size of muscle fibers and may, though it has not been conclusively verified, increase the amount of muscle fibers. Research also leans towards genetics playing a large role in one's fiber distribution levels, and may therefore predispose certain individuals to perform better at certain sports. Looking at world class athletes, this seems to be the case, with most having significantly more fibers of the type that benefits them in their sport.

The muscle-fat relationship is also important to understand. Muscle (1060 kg/m^3) is denser than fat (900 kg/m^3), so a more muscular individual will look thinner and more defined even if they weigh the same as a more fat individual. Muscle, however, does not replace fat. Fat is caused due to a consumption of more calories than are expended, while muscles are groups of tissue that are affected by the exertion of physical exercise and the recovery that follows. Further, each pound of lean body mass burns 13 calories/day at rest, so more muscle does promote more energy expenditure and therefore greatly assists in fat reduction.

Exercise is generally beneficial for individuals. A list compiled by Life Fitness on the benefits of exercise shows that it is truly far reaching. In general, it is good for overall health, weight management, and appearance. Mentally it boosts intellectual capacity, serves as a stress relief, and reduces anxiety. Functionally it increases one's general ability to move and do everyday tasks with less exertion, while decreasing the

chance of injury and increasing pain tolerance. Medically, it assists in disease prevention by reducing the chance of heart disease and stroke, reducing blood pressure, increasing good and decreasing bad cholesterol, and reducing the risk of developing colon cancer, breast cancer, type II diabetes, and lung disease. On the other hand, there are significantly fewer bad aspects to exercise, mainly, joint wear due to prolonged impact cardio (running). Also if exercise is done improperly it can lead to various problems (overuse injuries, muscle tears, faintness, etc.) and should therefore be initially done under the approval of a doctor and with a personal trainer to educate on correct methods of exercising. Finally, from a social viewpoint, sweating is viewed as an unwanted side effect of working out. (Reference 3)

Looking past energy expenditure, muscle development, fat, and general benefits, fitness itself can be addressed via prescribed fitness components and exercise factors. Fitness components are the fundamental building blocks required for a balanced fitness program. Exercise factors are the three components that effect muscle performance. Within fitness components there are the widely accepted health components as well as other varying subgroups that vary in name and attributes depending on what source is consulted. It is therefore only important to understand the former, which consist of: cardiovascular endurance, muscular strength, muscular endurance, flexibility, and body composition. Secondly, the exercise factors are: Strength, power, and endurance.

Within health components, cardiovascular endurance is the ability to use whole muscle groups for prolonged periods at moderate intensity using aerobic energy. This is important for developing a healthy heart and lungs as well as being the primary method of active calorie burning. Specifically, cardiovascular endurance increases oxygen

handling efficiency by increasing heart size which decreases resting heart rate and increases blood volume per beat. Resting breathing rate is also decreased and the volume of air exchanged for waste in the lungs is gradually increased. Finally the ability for blood to carry oxygen is increased. Currently it is recommended that this be done for a minimum of thirty minutes three days per week at an intensity varying depending on the goal of the workout. Cardiovascular effort is most commonly measured in terms of heart rate.

. The upper ceiling is determined by maximal heart rate which has been commonly been calculated as shown below. The research done in developing equation 1 is of questionable completeness as it did not include a sizable or varied test group and therefore its accuracy greatly decreases after the age of forty. A lesser known but more scientifically grounded equation is given in equation 2.

$$\text{Maximal Heart Rate} = 220 - \text{Age} \quad (1)$$

$$\text{Maximal Heart Rate} = 208 - (0.7 * \text{Age}) \quad (2)$$

Further, for measuring personal target zones in which one should conduct exercise, the Karvonen heart rate measurement was developed and is given below

$$\% \text{ Target Zone} = \text{DP} * (220 - \text{Age} - \text{MRHR}) + \text{MRHR} \quad (3)$$

where DP is one's desired percentage of effort from maximal heart rate and MRHR is one's morning resting heart rate calculated immediately after a restful night's sleep before one arises from bed.

Muscular strength is the muscles ability to generate large force in a short period with anaerobic energy. This is good for muscle and connective tissue size as well as long term weight control through increasing one's resting metabolic rate. The general concept

when weight training to increase muscular strength is to do low repetitions (eight) with high weight. Muscular endurance, on the other hand, is a muscles ability to generate force repeatedly using both aerobic and anaerobic energy. This reduces speed of fatigue in the muscular system and is accomplish by weight training doing high repetitions (twelve to fifteen) and low weight. Both of these health components are developed via resistance training and both contribute to the preservation of bone density. Experts recommend weight lifting two to three days per week for thirty to sixty minutes at a time.

Flexibility is the “absolute range of movement of a joint.” (Reference 4) Developing flexibility through stretching is arguably the most dismissed and improperly conducted fitness component, yet most research shows it is essential for strengthening the connections between muscles, decreasing injury risk, and lowering post workout tension and soreness. Additionally, though it is true of all fitness components, it is important to emphasize that flexibility is specific to each tendon and should therefore be done for the entire gamut of muscles being used.

Stretching has a relaxation effect on muscles and therefore the brunt of one’s stretching should occur mainly after a workout, following a cool-down, with each stretch lasting thirty to sixty seconds. Before a workout it is advocated that individuals warm up and then do only light stretching, holding for approximately ten seconds a stretch. Also, stretching should be done statically (holding) rather than ballistically (bouncing) because the latter is more apt to tearing tissue and causing injury.

Further, though current beliefs are in favor of stretching, certain recent research seems to show that excessive stretching is not beneficial. Also, research conducted by the Centers for Disease Control concludes, “There is not sufficient evidence to endorse or

discontinue routine pre-run or post-run stretching to prevent injury among competitive or recreational athletes." More conclusive research will surely be conducted to determine this. (Reference 5)

Body composition is the percent of fat, muscle, and bone in the body. Current numbers for normal individuals say that males should be between 5% to 20% while females should be between 12% to 25%. Obesity for men is considered above 25% and for women above 32%. Health is also often correlated to an individual's body mass index (body weight index or Quetelet index).

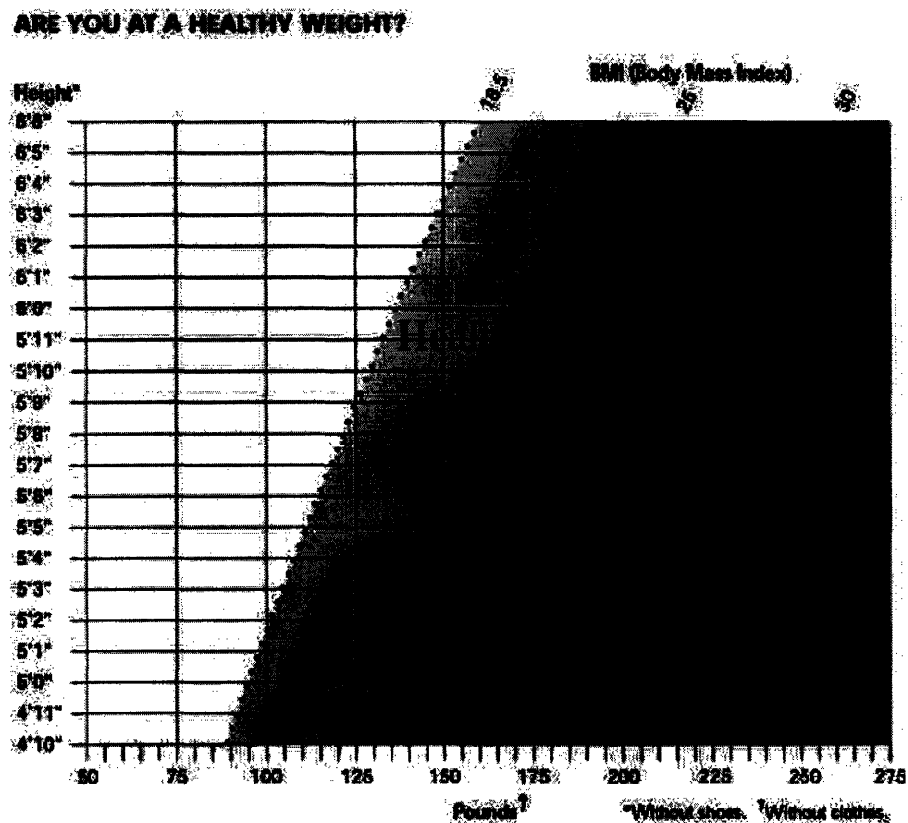


Figure 4: Body Mass Index Chart for Adults (Reference 16)

This is a very rough correlation for establishing an individual's "thinness" or "fatness" according to height and weight, and in recent times has been shown to be by no

means a final authoritative measure of such. (Reference 6) To accomplish proper body composition, individuals should implement the other four health components of fitness in a consistent fashion in conjunction with a proper diet and healthy lifestyle. It is also important to keep in mind that improving ones fitness level is not an instant process and for lasting results requires a minimum of eight weeks.

The three exercise factors recognized by fitness experts, strength, power, and endurance, are the three various ways to employ skeletal muscular tissue. Strength is the maximal force a muscle can develop. This is proportional to the cross-sectional area of a muscle. Power is the speed at which muscles develop maximum strength. Endurance is that ability to generate and/or sustain maximal force repeatedly. Though these are not mutually exclusive, each requires a certain type of workout to develop and depending on activity and goals most individuals focus heavily on one or two of the factors. As an example, sprinters require initial explosive power, while triathletes require sustained endurance, and body builders seek raw strength.

It is important to note that though our research does not touch on these, as mentioned earlier, there are extra skill-related fitness components that increase performance but are not essential to general health. Certain such performance components include: agility, the ability to change the direction of the body in an effective and efficient manner; balance, the control of one's body equilibrium while stationary or in motion; coordination, the ability to integrate various body parts with one's senses for smooth and effective execution; reaction time, quickness of response to a stimulation; and speed, the quickness at which a body part can be moved. As stated,

these are necessary for high level performance in many sports, but are not essential fitness components in relation to overall health. (Reference 7 & 8)

There are also a set of outside components that are essential for overall health, mainly the need for a proper and balanced nutritional diet, rest, and sleep. These, however, are also outside the scope of our fitness research.

Market

The \$60 billion worldwide fitness and wellness market is composed of the customer (immediate purchaser) and consumer (end-user). Specifically for the project, the former is the likes of Wal-Mart and SEARS, discount-superstores and department stores that serve as consumer “one-stop shops”. The project’s consumer is the everyday ordinary inactive home user. Because the former is open to selling any appropriate product, it is the latter that must be understood for proper and successful product development.

When it comes to sales, the customer is always right. When it comes to design, the customer’s need is always right. The end user has ideas on how products should be improved but no technical knowledge on implementing such and no inclination to inform the often unhearing ear of a manufacturer. Therefore, it is the designer’s job to actively seek to understand the consumer and get their thoughts on what improvements and innovations should be pursued. From a designer viewpoint one’s sight is often narrowed by all the technical and financial constraints that must be addressed in creating a successful product as well as the perceived needs acquired from being on the outside

looking in. By directly seeking to understand the consumer, the designer puts himself in a more knowledgeable position from which to address the problem.

In general, the developed nation consumer is leaning towards three trends: they purchase on want rather than need, they are willing to spend a premium on attractive well designed products, and the female in a relationship makes a substantial percentage of purchasing decisions. The consumer has the income to purchase outside the essentials needed for life and is often willing to purchase something wanted instead of better fulfilling needs; example, a nicer cell phone over more nutritious food. With these in mind, a consumer will pay for status, style, and quality and therefore the innovator, even when addressing the home market, no longer has a stringent pricing constraint, as in previous decades, requiring him to water-down products, but has an expectation constraint requiring the opposite, a requirement to provide exceptionally excellent products.

More specifically the home fitness consumer is the everyday individual who recognizes the benefits of physical activity but is unmotivated to consistently pursue it. It is the pre-gym and gym amateurs who want results quickly and easily, not the progressive gym intermediates, who understand that to get better they have to work for it, or the advanced muscle head, who make a living out of fitness, or the team sport athlete, who simply loves the challenge and activity. These individuals are not excluded from purchasing home fitness products, but are simply not the aim. Within the consumer, however, there are also sub-venues, mainly the home, the office, the automobile, and the suitcase. Each of these areas has different problems, requirements, and constraints in need of being addressed. In the home, most individuals would place their fitness

equipment in a garage, balcony, spare bedroom, and possibly but improbably personal fitness room. With this the main concern would be footprint size but no other such issues. The office on the other hand has space constraints as well as noise and sweat constraints, and therefore a more marketable product would probably involve balance and core strengthening rather than heavy strength training. The traveler requires a product that fits in a suitcase or backpack and it must therefore not be particularly heavy or bulky.

The project's fitness consumer is also a victim of laziness, often unwilling to admit that there is a problem in their lifestyle and hesitant to commit in a direction even when the problem is acknowledged. Further, they are part of a sedentary culture promoted by a media driven western society and spend a large part of life burning 1.5 calories per minute sitting in an armchair rather than standing (2 calories per minute) or walking (4 calories per minute at 2mph). Improper perceptions have also led many of the consumers to be intimidated by the strength side of the gym, not wanting to look out of place amongst "muscle heads" and not fully comprehending the methodology behind weight lifting. Also, female fitness consumers are hesitant about strength training, understanding the benefits, but afraid that doing anything past toning will lead to a less feminine "bulky" physique, despite research showing that females do not have enough testosterone in their bodies for this to occur without extensive resistance training.

Finally, though it seems ironic that with the countless benefits that come with exercise the products do not sell themselves better, the consumer's unwillingness to put forth effort, coupled with other minor issues such as sweat and fear of injury have made this a difficult consumer to reach. In reference to the Cybex Arc Trainer, a desk worker at the Boston University gym said, "We had a new type of elliptical machine here over

the summer, but people didn't like it because it was too hard." The consumer wants a quick fix, maximal benefit with minimal perceived effort.

Industry

Every industry has certain defining factors, certain stereotypes, notions, norms, and ideal products. Iconic symbols of the industry. For the team sports apparel industry, it's the grey T-shirt. For the fitness industry, it has been the treadmill, elliptical trainer, and Bowflex.

The fitness industry is divided into end-user groups and further into fitness subgroups. Specifically the divisions are commercial fitness, home fitness, and specialty fitness with each divided into cardio equipment, strength equipment, and specialty equipment. With such breadth there are few companies that have divisions in each section and therefore many industry leaders exist. (Appendix D) Throughout the history of fitness, advancements have generally begun at the commercial level, where expenditures are more flexible, and these products have been "watered down" into price-value innovated "home-versions" (eg. elliptical trainer). Occasionally the reverse will occur, with a good idea beginning for the home user and simply transferring over to the health-clubs (eg. Reebok Step, TreadClimber), and a few times the technology has initially been used in another industry (eg. health care) and transferred over into fitness (eg. treadmill).

The modern fitness industry actually begins at the inception of the treadmill in the post World War II era when research began to show the effectiveness of dedicated fitness

training and the usefulness of resistance training for athletes, innovating from the days of no-thrill treadmills to the current generation of media-driven exercise equipment.

Cardio machines, being the consumer preferred subgroup, have seen the most advancement in recent history due to their consistent market dominance, with most recent advancements emphasizing ergonomics, biomechanics, and low impact targeted at the elderly, injured, and non-runners. The original cardio machine, the treadmill, was initially developed in the late 1800s for use in agricultural power generation. It was then transformed in 1952 into an indoor walking-running medical testing machine, and only then recognized for its use as a fitness device. In the past ten years, the treadmill has been rather stagnant with the major advancements coming in adjustable belt cushioning and the incorporation of more sophisticated and intelligent displays.

Following the treadmill came the Lifecycle 2000 exercise bike in the 1970s, an upright design providing a small footprint, low impact, low jostle workout. The comfort of the general design is questionable, with the upright posture and saddle position being disagreeable to many. This has been addressed by the recumbent stationary bike design that provides the same general workout with a more relaxed seated position. The next large step came with the StairMaster StepMill in 1983, a mini-escalator, and later the FreeClimber, a more “low-impact” design with a vertically moving pedal system. Both have been criticized for not being particularly ergonomic and applying excess stress on the knee with the foot-knee-hip positioning that it promotes.

In the past decade, the largest cardio machine revolution has come in the form of the elliptical trainer developed by Precor in 1995. It attempts to mimic one’s natural running motion while being low impact and burning a comparable amount of calories to

running. Several newer products have attempted to take the elliptical to the next level or serve as a replacement low impact machine, all with limited success. The Cybex Arc Trainer, released in 2002, has modified the elliptical motion to create a more ergonomic feel that reduces joint stress by transferring more stress from the knees to the hips. The Nautilus TreadClimber Home Fitness Machine, released in 2003, doubles the calorie burning of regular walking with its two reciprocating belts that imitate uphill climbing. This product transferred up into the commercial level in 2005 with the release of the Nautilus TreadClimber and Bowflex TreadClimber.

Other recent competitors to the elliptical trainer include the Life Fitness Summit Trainer, released in 2007, which seeks to reproduce the feeling of mountain hiking and the Precor AMT 100i (Adaptive Motion Trainer), released in 2007, which provides adaptive stride adjustment. The TechnoGym Cardio Wave, released in 2005, has three plane motion (frontal, sagittal, and traverse), combining the elliptical and stepping motions to promote more “glute activation” in a footprint smaller than a standard elliptical machine.

Besides these, there are other machines that have not gained nearly as much attention as more traditional cardio machines, one such product being the indoor rower. Conceptually developed in the early 1900s it was not made practical until the early 1980s when air resistance ergometers were incorporated into the design. These machines simulate watercraft rowing and provide a more complete full body cardio workout. As compared to other cardio machines, indoor rowers require proper form and therefore have a rather steep learning curve. The Vasa Trainer, released in 1988, and more recently updated into the Vasa Ergometer in 2004, simulates swimming, allowing for the same

physical experience without the water or necessity for proper breathing. These machines, however, are not able to recreate all swimming strokes or the full body roll incorporated into each stroke, and as with normal swimming, require extensive work to develop proper technique. The original version used a pulley system and one's body for resistance while the newer version uses the same airflow technology as indoor rowers. Finally, along the same lines is the Vasa Kayak Ergometer released in 2007, which also using the airflow technology to allow for dry kayaking. (Visuals in Appendix C)

Even with all this advancement, cardio machines still have their problems. Display and controls have yet to be standardized among machines, even within companies, where control layouts vary depending on price-point and machine type. Button types, shapes, sizes, and positioning all vary. So do the displays that can be small or large, black-and-white or colored (red, blue, or green LED), and rather basic to highly sophisticated. This lack of standardization requires the consumer to adapt from machine to machine.

As compared to cardio machinery, the recent evolution of strength machines is more subdued with the new technologies not having created as large a response from the consumer. Isokinetic machines look to enhance strength training by incorporating smooth and controlled movement through out the range of motion. These machines allow for focuses on both strength and endurance but not power. Variable resistance machines such as the new Bowflex Revolution, aim to match the resistance applied, to the strength of the muscle throughout the range of motion, by using a cam design that changes the force as one's lever arm and mechanical advantage vary. The typical example for this is the bicep curl, where the moment arm blatantly changes though the

range of motion, being greatest when the arm is parallel to the ground and least at the top and bottom of the motion. The cam design creates limitations since the cam must be designed to match a certain length, which will vary from person to person. Biaxial strength machines have two axis motion to provide a more free weight like experience by incorporating stabilizing muscles along with the primary muscles for the exercise. Despite the advancements and benefits that these various machines provide, they have not yet become a consumer mainstay. (Reference 9)

Home workout machines originated in 1965 when Schwinn released the first such machine. Since then countless machines have been produced, with the Bowflex being by far the most successful. Originally released in 1986 as the Bowflex 2000x, the machine is renowned for its power rods that provide resistance by beam bending. The resistance type is dangerous in case of failure and does not provide constant resistance, with the resistance becoming more pronounced as the beam bends further. The Bowflex has undergone many iterations, most recently in 2006 with the release of the Bowflex Revolution that switched from the previous Power Rod technology to Spiral Flex technology that apply resistance through torsional deflection.

Fitness products are heavily made of hard plastics and steel box extrusions with rounded corners, vinyl upholstery, and conservative colors (gray, black, white, silver, dark blue, maroon). Product marketing within the industry also has a general feel. Most notably are the late night television infomercials, which though costly, they require a 10 to 1 margin return on a product to overcome the high marketing costs, are effective. Other common methods of advertising include fitness magazines, in store displays, and fitness center test runs.

As with any industry all companies claim to have the best products. Though this is obviously not true, in attempt to keep up with competitors, all similar products in the fitness industry always have similar features and any new successful feature added by a company finds its way into all the competitor's products in the following year's lineup. This is blatantly evident in cardio machines where each product has similar speed and elevation specifications, bottle holders, magazine stands, and heart-rate handgrips, with the next sure add-on to join this list being mp3 player integration.

This need for similar features has led the fitness industry to heavily replicated products either once patents expire or simply by finding a caveat within current patents. The most notable occurrence of the former occurred with the expiration of the Bowflex patent in 2004 which saw the release of the very similar BioForce TNT System. The latter however, exploiting patent loopholes, occurs much more frequently. The reality of this problem seems to be a hindrance to the fitness industry with market saturation and highly similar product options leading to confused consumers whose uncertainty leads to not purchasing. Along the same lines, false advertising in the industry with quick-fixes that claim to provide instantaneous results, have also hampered the industry by creating consumer suspicion.

Current Solutions/Technology

"Earth shattering products are hard for consumers to understand and consume". (Raphael Peck, Vice President for Product Creation at Under Armour) Therefore in developing new technologies one must strive to not only innovate but also to make it mentally accessible, acceptable, and cool to the consumer.

New technology has always had to undergo a rigorous path to come to market. Beginning with design and progressing through engineering, manufacturing, and supply; products usually begin as large aspirations and get progressively compromised as they continue through the pipeline and become a reality. One can mentally conceptualize anything, but to then address the mechanical and electrical realities for allowing functionality, fulfilling material requirements (yield strength, ductility, etc.) and fitting it within an affordable mass production structure requires compromise between quality and functionality with cost. Innovation within products is therefore often stifled.

These restrictions should not be lamented on, however, but rather embraced as a challenge and understood to prevent any surprises during the innovative process. Many highly innovative successful products have been released and are worth considering on why and how they were successful and then imitating as is practical and appropriate in one's own solution.

There are certain materials, appearances, technologies, and features that become "hot" or trendy and appeal to the consumer. Certain products have revolutionized their respective industries and deserve special attention when attempting to do the same in another industry. As a disclaimer, however, there are certain industries that have become ingrained with their own cultural and unshakable trends. The main examples of this is being the car industry where purchases are made mainly on style within a specific price range and, on the opposite side of the spectrum, the videogame industry where every new console is innovative and contributes something new to the industry.

Home appliances sales had stagnated in the past couple decades with very little technological innovation being made and prices dropping due to mass manufacturing and

decreasing material costs. With a culture changing towards buying on want and every room in the home becoming a status symbol, companies turned to design innovation to make more modern trendy appliances. These flashy décor matching appliances are epitomized by the glass-topped bathroom scale that provides the same function of any other scale but with a nicer appearance and more exuberant pricing. The cell phone industry saw a similar occurrence in 2004 with the Motorola Razr. The company set out to create the thinnest possible cell phone and developed a beautifully designed phone that compromised keyboard size and call quality for size. It became a huge success because of its flashy material selection, general look, feel, and size, despite its shortcomings as a phone and initial \$500 price tag. Apple began the same trend in 1999 in the computer industry with its G4 series computers that used flashy colors and acrylic casing to provide a sexy exterior to an otherwise unimpressive computer. Apple has continued this trendy attractive exterior design with great success. Beginning in 2001, the Apple iPod succeeded in defining and dominating the mp3 player market with a good feel, a nice design, and a highly acclaimed user interface. Others had had the chance to do the same, but Apple took the risk of increasing the pricing in exchange for increased quality, and in turn created a yet to be matched industry standard.

2002 marked a similar happening in the camera industry, with the Casio Exilim redefining digital cameras by being the first pocket-sized point-&-shoot camera. Flashy looks with mediocre quality at a steep price once again proved effective. On a slightly different note, the RIM manufactured Blackberry released in 1999 created a buzz by introducing a service everyone had been anticipating, practical portable internet access. And finally combining form, function, and simple user interface, is it any wonder why

there is such anticipation for the Apple iPhone which looks to integrate all major portable electronics into one stylish package, finally addressing the current issue of carrying and maintaining multiple portable electronics.

Moving to the realm of software, Google began its internet search engine dominance in 1998 by creating a search engine that provided a simplified user interface despite interior complexity. Google has since continued its dominance by integrating and improving all the major functions of the internet (search, pictures, videos, books, travel directions, calendar, documents, sketch, email) into its website. Finally, Napster's beginning of peer to peer sharing in 1999 succeeded because it provided the consumer what they wanted, the ability to easily share music and cheaply acquire only certain tracks, without forcing the consumer to leave the comfort of the home, purchase a tangible media disk, nor be force to purchase an entire CD or pay nearly the same price for a single. Finally, in apparel, UnderArmour, established in 1996, has become a successful business by creating a new industry, performance apparel, and relentlessly working to satisfy their consumer, the team sports athlete. As with all other quality products, UnderArmour, charges a premium for their products, which consumers happily pay. Among other feats, the company succeeded in raising average cleat price across the board, by \$20 a pair in their first season selling them.

Each of these products was not only well designed, but took a chance by taking large steps forward and rightfully charging a premium for their innovation. They were also, the first to do such in their industries. Many other products have attempted with much hype to follow each of these products (Motorola Krzr, Microsoft Zune, etc.) and mostly failed. From this the innovator should learn that consumers are willing to accept

new products and pay steep prices for them if they are notably innovative and user friendly, while once such a product exists, the consumer is hesitant to move on and let go of the original.

Certain other products have found themselves in a different conundrum, having been conceptually developed, but being too early for their time and lacking the technology to implement them into reality. An important example of this is Texas Instrument's Digital Light Processing (DLP) Technology, which was first developed in 1987 but was not realizable until the early 2000s due to an inability to manufacture the necessary micro-mirrors necessary to make it work. (Reference 11) If an innovator runs into such a problem, the product should be put aside for future addressing, but not entirely discarded.

The innovation that has been discussed in this section can be divided into three categories: Design, Technology, and Price-Value. Design is mainly aesthetic, changing the physical appearance of the product. An everyday example of this is cereal boxes, often made flashier and stating as such "New Packaging, Same Great Taste". In general this is the least expensive method of differentiating a product and arguably the most effective within the externally focused western world. Secondly there is technological innovation. The most complicated and expensive innovation type, it requires extra science and engineering of a product, to develop new mechanisms, software, or methodologies to improve on current workings. The computer chip industry sees this often, especially with Moore's Law still in effect, the number of transistors on a silicon chip doubling every 18 months. (Reference 10) Thirdly, price-value innovation involves using less expensive materials and manufacturing processes, and nearly

equivalent quality techniques, such as veneering, to reduce the cost of production and transfer savings on to the consumer. This is the innovation method most used in sports equipment and games to provide a near equivalent quality product at a significantly reduced price.

For these innovations to become a reality and for new technologies to be developed, research and testing is essential. Research and testing must be conducted in both “the classic, lab, setting as well as in an applied, customer testing, setting”.

(Raphael Peck, Vice President for Product Creation at Under Armour) The former is necessary for establishing credibility for a company’s products among the general public, educating the consumer, and future marketing, while the latter is more important for the actual quality of a product and for determining and addressing subtle product issues (pinch points, chaffing points, unintuitive uses, etc.).

A good example of this entire process is the evolution of the aforementioned Apple iPod. Beginning as a lower capacity hard drive mp3 player with a mechanical scroll wheel in the first generation, it progressed into a higher capacity mp3 player with a touch sensitive wheel for the second generation, to an even higher capacity mp3 player with touch sensitive buttons, a backlight, and a dock connector for the third generation, to a color screened photo capable mp3 player with the touch sensitive buttons incorporated into a click wheel for the fourth generation, to a higher capacity video player with a slimmer design, larger screen, and the addition of a black exterior color for the fifth generation. The iPod has been a progressive effort to develop a more user friendly product with constantly evolving design and technology innovations. If a product is really to be a success it should be initially well designed and then progressively iterated.

This is especially necessary in technological industries where general advancements are consistently made and products become obsolete after a prescribed time period. Within the fitness industry, the Bowflex has done this best by constantly improving on the design.

If a product is to be a major breakthrough and success, it must take a calculated risk, be aesthetically appealing, and constantly be revised and revamped.

Design Process (Specific)

For developing the next “wow” fitness product from the ground up, one needs to be thorough and extensive at each step of the design pipeline. At the beginning, the open-endedness of the task, necessitated that research be done in conjunction with the development and refinement of need/problem statements. Even in the later stages of conceptualization, the breadth of need/problem statements and therefore solutions varied such that continuous research and broad thinking was required. In retrospect, this does not seem to be the most effective way to address such a large task, which should have been inherently narrowed to at least one of the subgroups (cardio, strength, specialty) within the fitness industry. On the other hand, the breadth of the problem required research that developed a very good foundation for the industry and that will be beneficial when doing similar tasks within the industry in the future.

-Research

Initial research came in the form of fitness company websites, gym visits, and retailer visits. The websites provided an initial broad spectrum of what generic fitness products are in existence (many) and what unique fitness products are produced (also many). Certain trends were seen in the former with a sense of what was needed to create differentiation from competitors seen in the latter.

Extensive webs searches produced a substantial amount of good and bad websites, with several exceptional resources. In terms of visual quality and presentation, Life Fitness is the most noteworthy company, stylistically distinguishing themselves very well with exceptional industrial design in their products and a website of notable quality that

provides substantial amounts of text and visual information. It was interesting to note that Life Fitness, as well as a few other industry manufacturers (Cybex, Precor, Octane Fitness), had expansive experimental research resources on their websites. Each of these resources had an inherent lean in promoting the specific company's products, but still served useful. Government, university, and reviewer resources, however, served better in providing more objective looks at products and technologies as well as providing good background information on fitness.

For on site research, four different local gyms were visited: MIT Zesiger Sports and Fitness Center, Boston University Fitness and Recreation Center, Northeastern Marino Recreation Center, and Kendall Square FitCorp Gym. The larger university gyms proved more beneficial in providing a broader scope of available products, allowing for more extensive and varied (different user levels) user-machine interaction observations, offering a better look at machine wear, and providing a look at the social aspect of fitness. Of most importance in visiting the smaller gym was to see how differences in available space vary commercial gym layouts. Speaking to general employees and trainers at these various locations, it was interesting to note that they all had similar consumer observations and equipment requests. All the individuals noted that the cardio equipment was more popular among consumers, that strength equipment was more heavily used by men, and that most individuals were in the gym for approximately an hour at a time. In terms of requests, there was a common desire for mainly cardio equipment ranging from ski machines, swimming machines, skating machines, and cardio machines that provided a more substantial upper body workout. It is also interesting to note, that most of the machines discussed and requested were already in existence at some level, which brought

into question whether the problem with these machines is lack of consumer interest, poor marketing, or poor implementation. Less common products observed at these locations included: the Cybex Arc Trainer, Nautilus TreadClimber, and TreadWall (10' "recycling" climbing wall), which were all briefly used and viewed while in use by consumers. In a nice bit of luck, each gym had a different main manufacturer that they ordered equipment from, allowing the use of various implementations of the same product ranging from treadmills to pull-down machines to weight collars. As far as wear, the expected high use, high load parts were observed as being worn down. In cardio machines these were the belts and foot pedals, while in strength equipment, it was the padding, handles, plate holders, dumbbell faces, carabineers, and selection pins, most of which are easily replaceable. The social aspect of the gym was also interesting as the low-impact cardio machines promoted constant multitasking whether socializing, TV watching, or reading, while treadmill running was much more solitary and weight lifting more shifty, with normal interaction occurring between sets and more motivational interaction occurring during sets.

Retail research was limited to SEARS, Target, and CitiSports, where it was observed that all gym equipment is piled into a relatively small area displays reserved for larger machines. No sales representatives were approached on their thoughts of fitness products and customers.

Interesting technologies within the industry were also important to research and found mainly through infomercials and internet searching. The obscurity of many of these products speaks to their lack of commercial success and a list is provided in Appendix F.

Research included conversations with family, friends, and individuals of all activity levels on their ideas on fitness, what fitness equipment should exist, and how current fitness equipment could be improved. The results were mostly similar to speaking with the gym desk workers, with only the more consistent and advanced gym individuals having any unique ideas. More specific results of the research conducted are detailed within the research section of this document.

-Initial Concepts

Having conducted extensive research, it was necessary to begin solidifying actual need/problem statements. These were accumulated from the conducted research and compiled in a list of “What If” statements spanning the three fitness subgroups organized into various categories that aimed to encompass possible new products as well as significant improvements to current offerings. The initial “What If” list is provided below:

"What Ifs"

CARDIO EQUIPMENT IMPROVEMENTS

Vasatrainer could do core rotation
Vasatrainer also strengthen your hand
Elliptical trainer worked arms separate from the legs
Elliptical trainer provided serious arm strength training
Treadmill track was adjustable to various terrains (san, grass, etc.)
Treadmill could also become a stepper or stretch mat
Recumbant bikes had massaging back feature
Cardio machines had mister for body cooling
Cardio machine handlebars were better positioned
Cardio machines had soft, gel-like handlebars
Cardio machine handlebars weren't unpleasant when sweaty
Cardio machine handlebars provided massaging feature
Cardio machine was quieter
Cardio machine had voice controls
Did not have to touch console to adjust speed/incline

WEIGHT TRAINING IMPROVEMENTS

Hybrid Smith-cage machine
Bench/Squat cage had pulled cabling attachment on end of bar
Assisted bench press equivalent to real spotter
Bench incorporated balance ball-esque core stabilizing
Weight stacks didn't clink when they made contact
Equipment padding did not tear
Equipment padding worked better with sweat
Equipment had transparent or translucent look
Pull-down bar did not cause hand callouses
Stretching incorporate into benches
Acrylic for dumbbells and plates

ALL-IN-ONE

Elliptical trainer also a recumbent stationary bike
Machine combined both muscular strength and endurance
Machine combined balance, flexibility, and strength

OTHERS

Weight grips/gloves that go directly on weights, not hands
Portable mirror system
Pull-up bar more accessible to short people
Human power machine
Machine did all the work while individual just sat
Machines generate electricity for powering lights, electronics, etc.
Machine made of recycled materials

NEW EQUIPMENT

Cardio machine mimicked mogul skiing
Cardio machine mimicked slalom skiing
Cardio machine mimicked rollerblading
Cardio machine mimicked swimming
Cardio machine mimicked slick board motion
Cardio machine mimicked canoeing
Wrist-Forearm machine
All-in-one bench
Incline & decline bench
Chair or couch that is also a bench
Chair or bed with light exercise for rehab or elderly
Resistance vest with elastic bands
Stretch helping machine
Recumbent elliptical trainer
Stationary bike combined with heavy bench press
Lay down cardio machine
Treadmill with hurdle trainer
Communal treadmill
Communal resistance machine (1 person resists, other exerts)

PORTABILITY / STORAGE

Turnk sized cardio machines (rower, elliptical trainer)
Workout while driving
Folding elliptical trainer
Entire gym set in trunk of car

GADGETRY

Internet/streaming radio on cardio machine
Check email while working out
Play videogames while working out
Charge iPod & cell phone while working out
Nature sounds for cardio machines
Cardio machines felt as if outdoors
Cardio machine sensed heartbeat without a strap
Cardio machines had built in FM receiver
Treadmill weighed you automatically
Machine would detect incorrect/improper motion
Wear virtual goggles while on cardio machine
Cardio information presented as something more tangible

Figure 5: "Wow" Fitness Product "What If" Sheet

Now having an effective set of need/problem statements, rough sketching many of the problems and conceptual solutions provided a general look and feature set for each product concept. (Refer to Appendix B)

-Round 1

These rough sketches and “What Ifs” were presented to an industry representative to do extensive narrowing according to the project’s market, current needs, and vision.

Eight major categories were settled on as possible products:

An all-in-one bench with a new integrated constant resistance system

An elliptical trainer engineered for easy assembly

A three-in-one elliptical, stepper, Arc Trainer machine

An elliptical trainer with a new look and adjustable feel

Integration of resistance training into an elliptical trainer or treadmill

Integration of an elliptical trainer and stationary bike

A resistance vest allowing for core strengthening and upper body training

Intelligent workout gloves capable of tracking workout information

-All-in-One Bench with Resistance

When it comes to benches there are standard flat benches, adjustable incline benches, adjustable decline benches, adjustable incline/decline benches, an assortment of bench press benches, and benches similar to the Reebok Deck. The Reebok Deck is the next generation Reebok Step, which integrates the Step with an adjustable bench serving as both an aerobic and strength training system. Along with free weights, the Deck has various attachment points on the underside for resistance cord attachments. Elastic cords

and bands are a popular lightweight method of adding resistance, however, as with the Bowflex power rods, they provide uneven resistance, with insignificant resistance initially and increased resistance as they become more stretched.

This idea therefore seeks to incorporate a refined all-in-one bench design, aiming more at a serious strength workout with a more consistent lightweight resistance method. Though the concept of a modified all-in-one bench is in and of itself innovative and has a viable market, it would lack the “wow” factor that is integral to this entire project. The important part is therefore the resistance. Current resistance types include: Free weights (traditional, bars, kettle bells, medicine balls, xerballs) , cables-pulley-weight stack systems (traditional, powerblock), elastic bands, power rods (Bowflex technology), torsion plates (Bowflex Revolution technology), body bars (high frequency vibrating bars), electromagnetic systems, hydraulic systems, and ergonomic (air flow through fins) systems. None of these is particularly satisfactory for use with an all-in-one bench either due to excessive size, weight, price, or inconsistent resistance. So along with developing the bench, a new method or combination of current methods of resistance must be developed for working in conjunction with the bench.

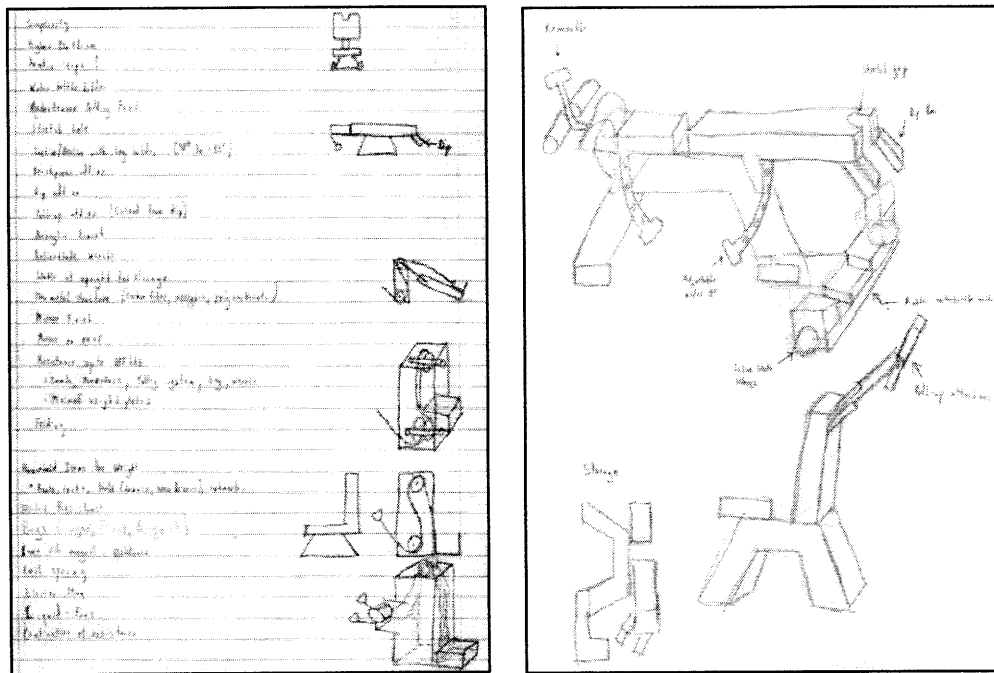
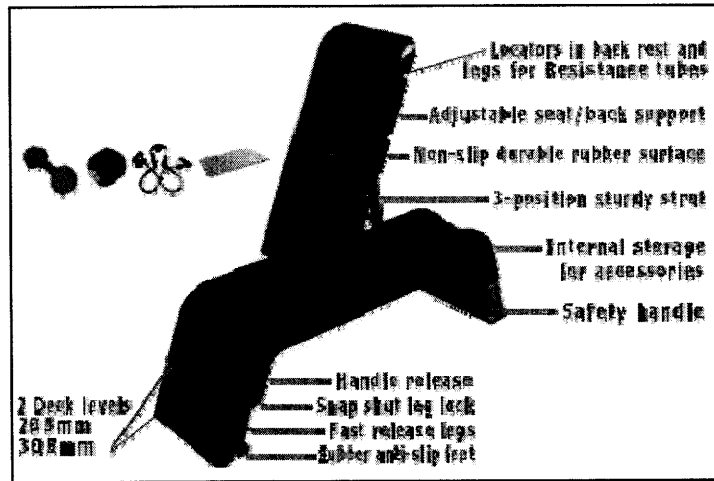


Figure 6: Initial all-in-one bench concepts (bottom)
Reebok Deck (top)

-Simplified Elliptical Trainer

For better engineering an elliptical trainer, it would be necessary to use simple fasteners for providing fast and simple construction of an elliptical trainer shipped in parts. The main reason for such a design would be to create a product shippable in a

smaller container by decreasing the number of parts and using tool-less fasteners such as flexures, snap fits, and wing nuts. Such a problem would also involve addressing the general design of the elliptical, attempting to further reduce the length and footprint as well as providing a more aesthetically pleasing look. Currently, however, the main size constraint is the flywheel and its encasement, which without being fully redesigned cannot be greatly changed or simplified.

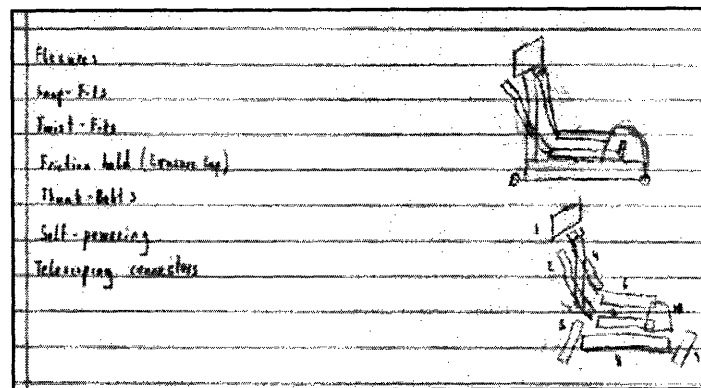


Figure 7: Initial simplified elliptical concept

-Three-in-One Step-Arc-Elliptical

A three-in-one step-arc-elliptical would be marketed as the next step in the elliptical trainer evolution, providing user adjustability in a machine comparable in size to a normal elliptical trainer. To address the problem it is necessary to be able to rapidly change the motion by an electric system, adjustable gearbox system, interchangeable cams, or other method. The complexity of such a problem comes in devising an affordable system that is adjustable while in use.

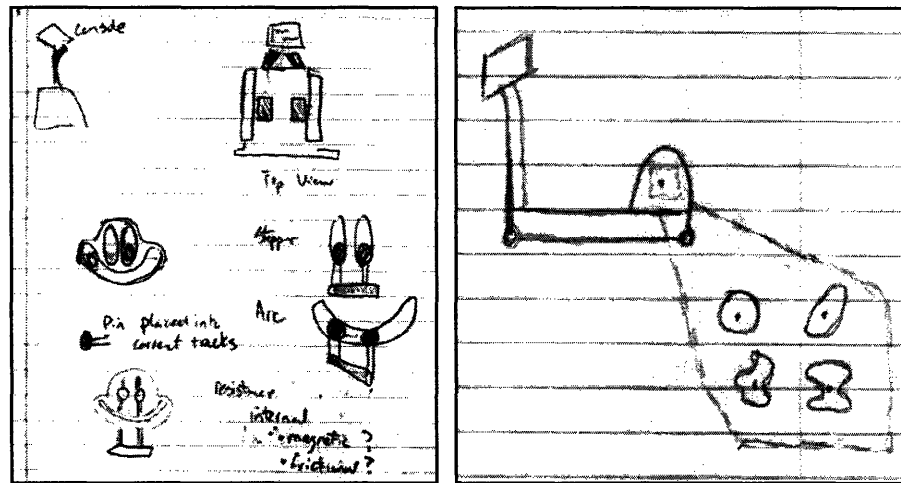


Figure 8: Initial 3-1 elliptical concepts

-New Feel Elliptical Trainer

Elliptical trainers use a supposedly ergonomic and biomechanically correct ellipse motion. However, the thoroughness of this research is in question and the project behind this idea would be to study biomechanic and ergonomic research done by others and conduct expansive theoretical and user testing, to optimize the elliptical motion's feel.

-Cardio Machine with Strength

Effectively combining a cardio machine with strength training equipment has yet to be accomplished. Various attempts have been made, all proving to be unsafe, ineffective, or unpopular. And though no machine has fully succeeded in addressing the strength during motion aspect of the problem, it is necessary to think of the home-user as well and attempt to incorporate a multigym with a cardio machine. The main problems with this is providing variable resistance without greatly increasing weight (whether by using the current motor or adding another system) as well as incorporating useful exercises without adding footprint size.

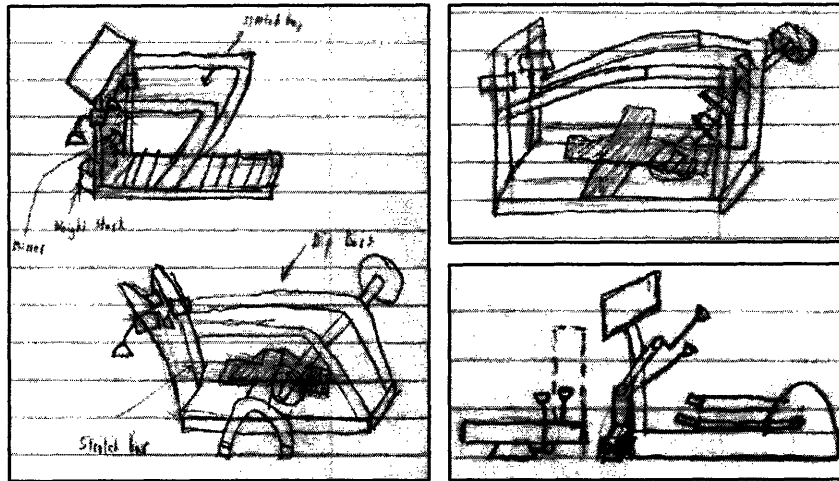


Figure 9: Initial cardio with strength concepts

-Combination Stationary Bike-Elliptical Trainer

Though the treadmill is the standard of cardio equipment, the stationary bike and elliptical trainer are the cardio machines of choice for low impact workouts. To combine the two, would provide the home-user the diversity and benefits of both machines in a more affordable and space saving design.

-Resistance Vest

Various boxers have been known to use body speed training systems that amount to weighed body vests with resistance cords attached. This concept, however, has not caught on with other groups. However, if it was possible to provide a wide range of upper body and core exercises in a resistance vest package, it would be marketable to the larger aerobic crowd.

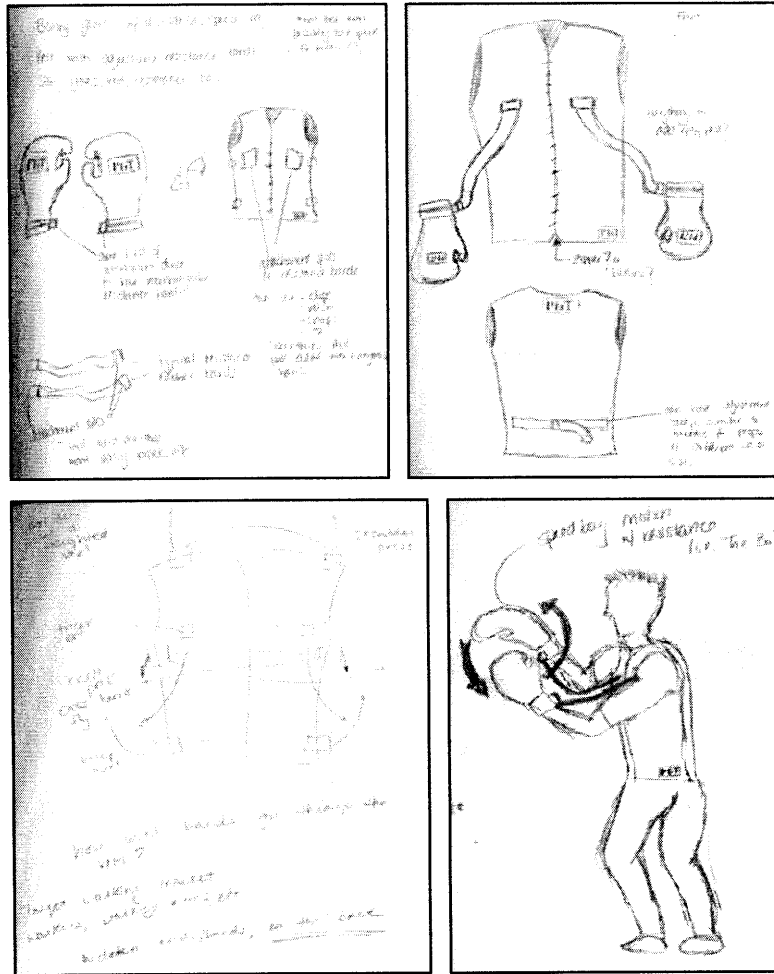


Figure 10: Initial resistance vest conceptualization

-Sensing Gloves

With the new innovation of the Nike+ system, which integrates a shoe sensor with the Apple iPod Nano to provide instantaneous information during runs, it seems natural to expand such technology to other aspects of workouts. The initial idea is to have intelligent workout gloves that measure general data such as weight lifted, repetitions, and sets, with the possibility of expanding depending on complexity.

-Round 2

With eight general ideas, the next step was to compare each idea to the “What Ifs”, further conceptualize each idea to gain a clearer idea of what exactly would be necessary for making the ideas feasible and then further methodically narrowing them via their performance against a criteria sheet. The concept sheet is found in Appendix A, and the criteria sheet is below:

	Bench w/ Strength	Minimized Elliptical	3-1 Motion Elliptical	New Feel Elliptical	Elliptical w/ Strength	Treadmill w/ Strength	Resistance Vest	Sensor Gloves
Wow Factor	+	-	+	-	+	+	-	+
Feasibility	+	+	-	+	+	+	+	-
Similar Products	-	-	0	-	0	0	-	+
Footprint	+	0	-	0	0	0	+	+
Perceived Cost	0	0	-	0	0	0	+	-
Shipping Cost	0	0	-	0	-	-	+	+
Cardio	0	+	+	+	+	+	+	0
Resistance Training	+	0	0	0	+	+	+	0
TOTAL	3	0	-2	0	3	3		2

Figure 11: “Wow” Fitness Product Criteria Sheet
Base varies

Presenting this information to our industry liaison led to narrowing to four ideas: resistance vest, all-in-one with treadmill, sensor gloves, and unique resistance. The others were decided to not be in accordance with the required price range and target customer (3-in-1 elliptical), not have enough “wow” factor (minimized elliptical, new feel elliptical), be too similar to another product (all-in-one bench, 3-in-1 elliptical, minimized elliptical, new feel elliptical), or be too complicated to be address in the allotted project time (3-in-1 elliptical). Of the concepts that were kept, various notes were made.

The resistance vest was decided to be too bulky to be marketed to travelers, too unadvanced for athletes, and too normal for infomercials. The decision was therefore to develop the product with the power walker and walking mom markets in mind.

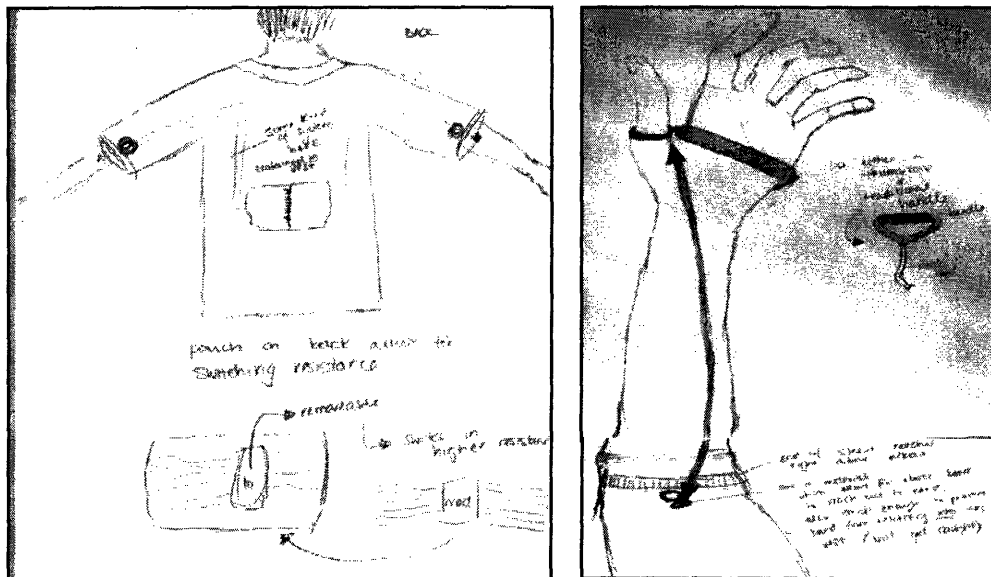
The multigym (all-in-one) with treadmill was decided to be most marketable as such, rather than the previous wording, and more accurate, treadmill with multigym. The idea would be aimed at the home users with a full-fledged treadmill and an array of upper body workout options. The footprint is key and therefore everything must be fit within the current size constraints of a usual treadmill.

Though the sensor glove's electrical and computer science emphasis present a design challenge, its novelty and the recent success of the Nike+ deem it worth exploring for feasibility, cost, power requirements, capabilities, user-interface, and general implementation. Simplicity is essential for ensuring both affordable pricing and straight forward user-interface. Though the Nike+ does have strong company branding and heavy marketing behind it, the reason it is succeeding in selling technology that is at least half a decade old are the low cost, seamless iPod integration, simple calibration, and easy user-interface. For the sensor gloves to succeed, they will have to follow suite.

As stated earlier, developing a new method of resistance would be integral to the all-in-one bench. Taking this further, the idea will now be upscaled to a unique resistance system to replace weight stacks in multigyms and other weight machines, similar to what electromagnetic resistance and hydraulic resistance have attempted to do.

-Resistance Vest

After more research and conceptualization, the following was conceptualized. The resistance vest should be developed as a weighed, heavy duty, long sleeve workout shirt made of performance apparel material. Refining the initial design and doing some elastic band testing, it was decided that the power walker requires three main resistances for appropriately increasing their upper body workout's intensity. These three areas are bicep, tricep, and shoulder resistances. The resistances would be provided by built in elastic bands that can be hooked to provide resistance or be disconnected for normal use. Heavy stitching would be essential at all seams and all elastic attachment points to ensure prolonged life. The diagrams below visually demonstrate this.



-Multigym with Treadmill

The multigym with treadmill was developed around a full size folding treadmill. Currently treadmill side support bars are required to support significant weight with a large safety factor because of their human bearing use. The idea is to build the gym around these, incorporating a dip bar, and a standard, decline, and incline bench press

setup. An all-purpose folding bench would be stored under the console and an olympic bar under the treadmill. The underside of the treadmill would have a reflective mirrory surface for use when folded up. With this, one would run on the treadmill, then remove the bench, fold up the treadmill, set down the bench, setup the bench supports, and do bench press. With the built in mirror and lowering the bench press supports, the consumer could do any free weight exercises, and could also incorporate dips on the treadmill side supports.

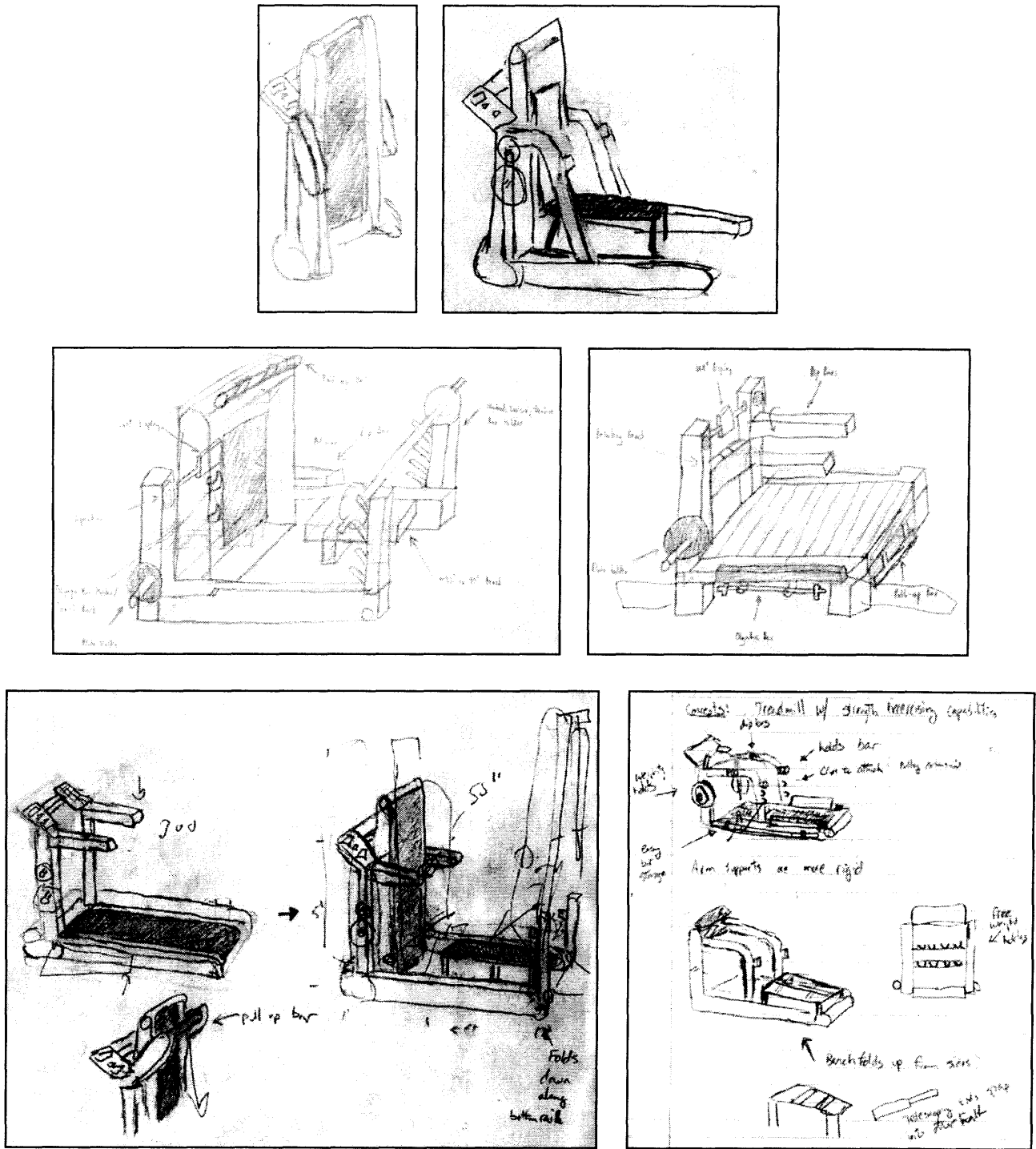


Figure 13: Advanced multigym with treadmill concepts

-Sensor Gloves

The sensor gloves proved to be even more complicated than expected, with each general implementation type having its own pros and cons. The first step was to look at similar products, mainly the Nike+ system and Polar F55 Heart Rate and Running system. The former is aimed at the recreational runner and priced at \$30. It is composed of a receiver that attaches to the iPod Nano and a sensor that goes under the insole of specially constructed Nike shoe. There is also a third party pouch that attaches onto any shoe's laces. The sensor still works in this configuration, but it has been noted that it is less accurate, which can most likely be attributed to the angle on the sensor and the different amount of depressing that occurs in this configuration. The sensor itself is a piezoelectric accelerometer that detects and correlates contact time with running pace. It runs on a 20mm Lithium coin cell battery and uses 2.4GHz bandwidth for broadcasting a signal each time the sensor is depressed. The battery lasts approximately 1000 workout hours and the transmitter emits to about 40 feet, an excessive distance that may be reducible to increase battery life. The Polar F55 is significantly more expensive than the Nike+, at around \$220, but rightfully so with its extensive feature list and its aim at the more serious athlete. It uses the same 2.4GHz bandwidth for data transmission. As stated, the system incorporates a lot of advanced features most notably "Polar Body Workout", which gives very basic guidance for strength training workouts via the watch display. Also of note is the Polar MobileLink system, which allows certain Nokia phones to be used in conjunction with the F55 to serve as a large screen exercise manager.

As far as sensors required for upper body weight, set, and repetition information gathering, pressure sensors were found to be necessary at six specific contact areas for

calculating weight (depending on how much the sensors are depressed) and in part, the exercise type (depending on which set of sensors are depressed).

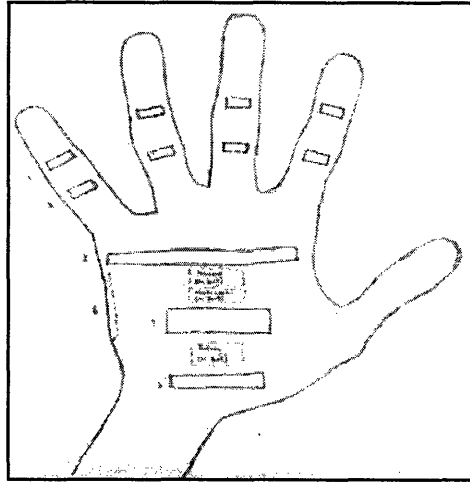


Figure 14: Initial sensor locations in sensor gloves

Along with these, it was initially thought that a 3D positioning system would be required but instead it was decided that the same could be accomplished by calibrating a common zero-point for the gloves and using 3-axis accelerometers. Calibration of the pressure sensors will require calibrating to a weight and calibrating for grip strength, with the latter being important because of its variance not only from person to person, but also due to hand fatigue. The initial thinking was to have an LED on the right glove to visually indicate on/off, standby, calibration, etc. and transmitting all the information obtained from the gloves to a heart rate strap which would have a receiver, microprocessor, and a USB connection to upload data to a computer. USB data transmission was favored over media cards and wireless because of the extra equipment costs of these latter two, the requirement of having further technology on the computer (a media card reader or

wireless receiver), and the advantage that USB cables can also be used for battery charging.

-Unique Resistance

For the new unique method of resistance, it was thought that using magnetic forces created by electromagnetic setups would be a good avenue of approach. This would essential have a conductive block of material within an outer frame coiled in electrical wire. The coil would create a force in the downward direction through which the conductive block would be pulled. Though the direction of resistance would not be required to change at the top (initially incorrectly thought, but the force should always be downwardly applied), it would need to be decreased to prevent excessive downward acceleration due to the magnetic force working in tandem with gravity. Such a design would be used as a weight stack replacement, with the advantages being its small footprint, relative lightweight (as compared to a weight stack), and its variable resistance throughout the range of motion. Disadvantages would be the need for a wall outlet connection for each of these electromagnetic “weight stacks”, its high current draw, and the generation of a large magnetic field. The last problem alone is significant and not practical seeing that no electronics or magnetic metals would be allowed within a given distance of the machine.

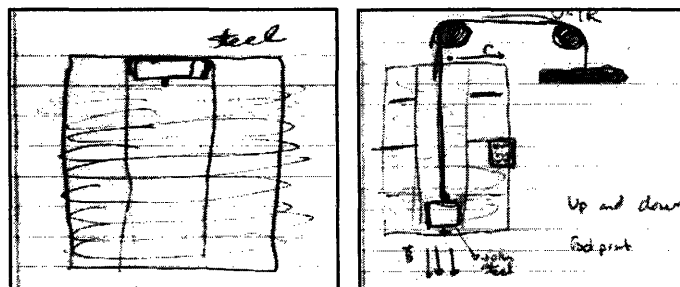


Figure 15: Unique electromagnetic resistance concept

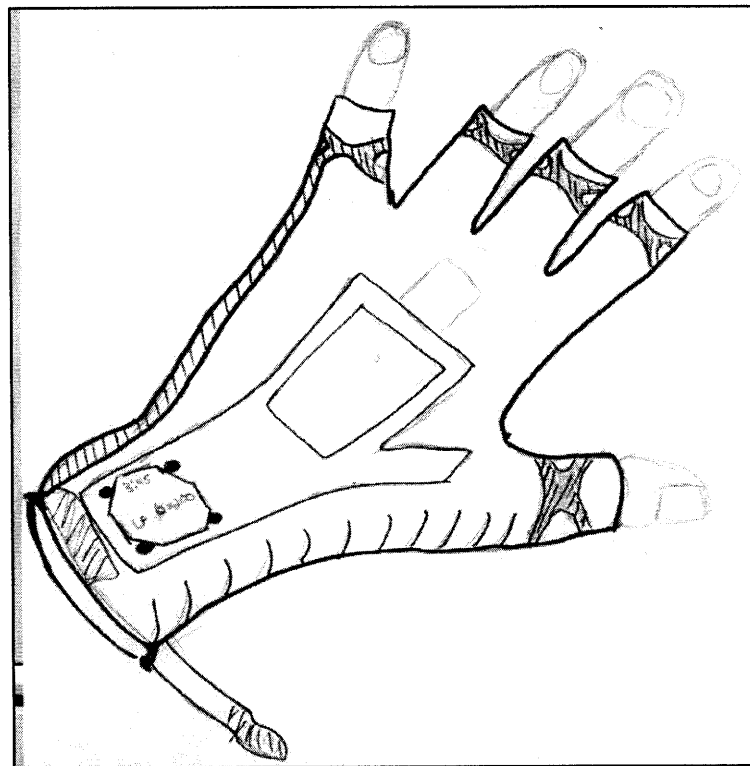
-Round 3

Meeting again with our industry contact, the sensor gloves and unique resistance system were opted to be kept. The sensor gloves seemed the most practical to fully conceptualize with the remaining time left in the project, while the unique resistance could have such extensive value that it was worth further researching. On the other hand, the resistance vest, though promising, was felt to require an apparel company's branding for proper marketing. Also a similar product, the Hammer Strength Training Vest, was released that week, decreasing its uniqueness. The multigym with treadmill was ended due to its inherent complexity which creates a plethora of subtle issues (safety, pinch points, sharp edges, complicated mechanisms, etc.) that would hard to address without a prototype.

-Final Concept: Sensor Gloves

Another week of work, and it was decided that the complications of the unique resistance system proved too large and it was dismissed. The sensor gloves were further discussed and it was decided that the only way they could truly succeed would be by providing at least the option to be a full body system, upper and lower body, and if it served more as a fitness coach with the ability to record information rather than a paper and pencil replacement that also happens to be a fitness coach. After further research, consulting, and conceptualizing the concept was fleshed out and compiled into a highly developed concept document addressing all the issues and implementations for the sensor gloves.

Product Concept: Sensor Gloves



MIT Center for Sports Innovation
Jorge Renjifo
Chris Desrochers
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Introduction

The Weight-Sensing Gloves have the ability to record and sense a variety of pertinent weight-lifting information for a wide range of exercises. The data is then imported into a software program that translates the information and allows the user to track current and previous workouts.

The gloves will be aimed to be sold retail at \$150, with a further leg attachment retailing at \$40.

The following exercises should be recognized and detect the weight:

- Bench Press (BP regular, IBP inclined, DBP declined)
- Pull-downs (PD)
- Pull-ups (PLLU)
- Push-ups (PSHU)
- Dips (DP)
- Shrugs (SH)
- Front Raise (FR)
- Tricep Extensions (TX)
- Bicep Curls (BC)
- Military Press (MP)
- Seated Rows (SR)
- Bent-over Rows (BOR)
- Fly's (F)
- Wrist Curls (WC)
- Lateral Raise (LR)
- Dead Lifts (DL)
- Reverse Fly (RF)
- Trunk Rotation (TR)
- Side Bends (SB)
- Cleans (CLN)
- Clean and Jerk (CLNJ)

The following exercises should recognize repetitions but require the input of the weight:

- Leg Press (LP)
- Leg Extensions (LX)
- Leg Curl (LC)
- Squats (SQ)
- Adductor (ADD)
- Abductor (ABD)
- Calf Raises (CFR)

The following exercises are not supported:

- Sit-ups
- Crunches
- Leg Lifts
- Flutter Kicks
- Lunges
- Pushups

Mechanical Information

LED

The watch will feature an On/Off button. When the watch is initially turned on by holding the button for three seconds, an LED will be solid orange while it senses signals from the gloves. The LED will then flash orange at which point sensor calibration is done. Once the gloves are ready for use, a solid green LED will be lit. To turn off, press and hold the same button for three seconds, the LED will flash two long red flashes and then shutdown.

During use, the LED will flash green after each repetition (when it reaches the lowest point of the repetition or closest point to the body during the repetition). Low battery will be indicated by the LED flashing red.

When the watch is plugged into the computer and charging, the LED will flash orange while charging and be solid green when fully charged.

Sensors

Each glove has six separate pressure sensors for weight detection located on the middle finger below the upper joint (1" by .25"), on the middle finger below the middle joint (1" by .25"), on the hand below the lower joint of the middle finger (1" by 1"), in the palm (1" by 1"), on the hand slightly above the wrist (1" by 1"), and on the bottom of the fist (1" by .5"). Each sensor must be rated for 11 MPa and the suggested manufacturer is Emfit. Each glove also has a 2-axis accelerometer on the back of the wrist for repetition detection. Data transmission will go from the glove to the watch via 2.4GHz wireless transmission. Each glove will be powered by a AAA battery located on the back of the palm.

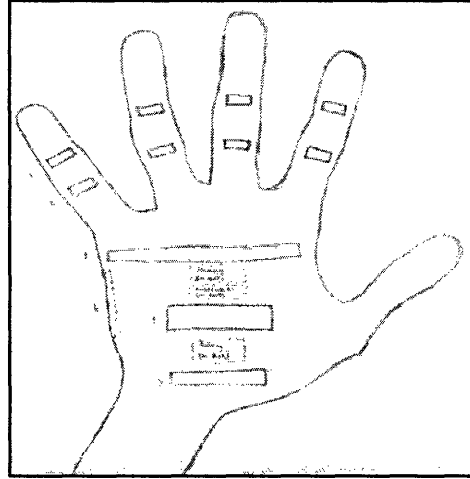


Figure 1: Sensor Locations

The separate leg attachment ankle bracelet will simply have a 2-axis accelerometer, a AAA battery for power, and a 2.4GHz wireless transmitter.

The watch will serve as the system's hub, receiving the wireless data, performing the most essential of calculations, and displaying various bits of data on the display. The underside of the watch will have a heart rate monitor. The entire watch-microprocessor, will be powered by a standard CR2020 battery (\$5).

While there is no accelerometer motion and pressure input the gloves will enter a standby mode. Once in standby mode, no data will be recorded or processed by the watch component. User will need to make a tight fist and hold for several seconds in order to reactive the sensors and start the next exercise.

The ribbon piezoelectric sensors and accelerometers will require to be water resistant at the least and possibly water proof for washing purposes. The watch itself will disattach from the gloves for washing.

Calibration

The pressure sensors will be calibrated by grasping a ten pound weight and holding it at one's side. The user will then squeeze hard for five seconds to calibrate for grip strength. The accelerometers are calibrated while holding the arms at one's side, setting this as the zero point. The leg attachment will be calibrated by standing still also at the same time.

Display

The left glove will have a watch attached at the end of the glove, similar to the Polar F55 (\$240), with an inch by inch display. The screen will cycle through four main menus: Time/Date, Workout, Chronometer, and Count Down. The workout screen will display the most recent exercise, number of repetitions, and weight used for the set.



Figure 2: Polar F55

Buttons

There will be five buttons on the watch: On/Off, Mode, +, -, Set. The On/Off will turn the system on and off, the mode will switch between the four watch modes, the +/- buttons will serve for adjusting weight during leg exercises, setting the time, etc. The Set button will be used as a select button.

Connectivity

The watch will connect to a computer via mini-USB which will serve for data transfer as well as recharging the watch's battery. It will be aimed for compatibility with at least Windows XP/Vista compatibility.

Care/Washing

The sensors should be waterproof initially, but gradual wear will reduce this ability.

Therefore it is suggested that the glove be Febreezed and air dried after every workout.

Material

The gloves will be made in the style of the Under Armour Z1 Heatgear Receiver Gloves (\$30) with added Silver nanoparticles for antimicrobial purposes



Figure 3: Under Armour Z1 Heatgear Receiver Gloves

Software Information

The software will be setup in the style of excel spreadsheets incorporating parts of the Nike+, Polar Personal Trainer, and Progio interfaces. Software will allow to view information on each workout individually as well as track progress and see trends via charts and graphs. The data output will aim to provide the most pertinent information initially but will be fully customizable.

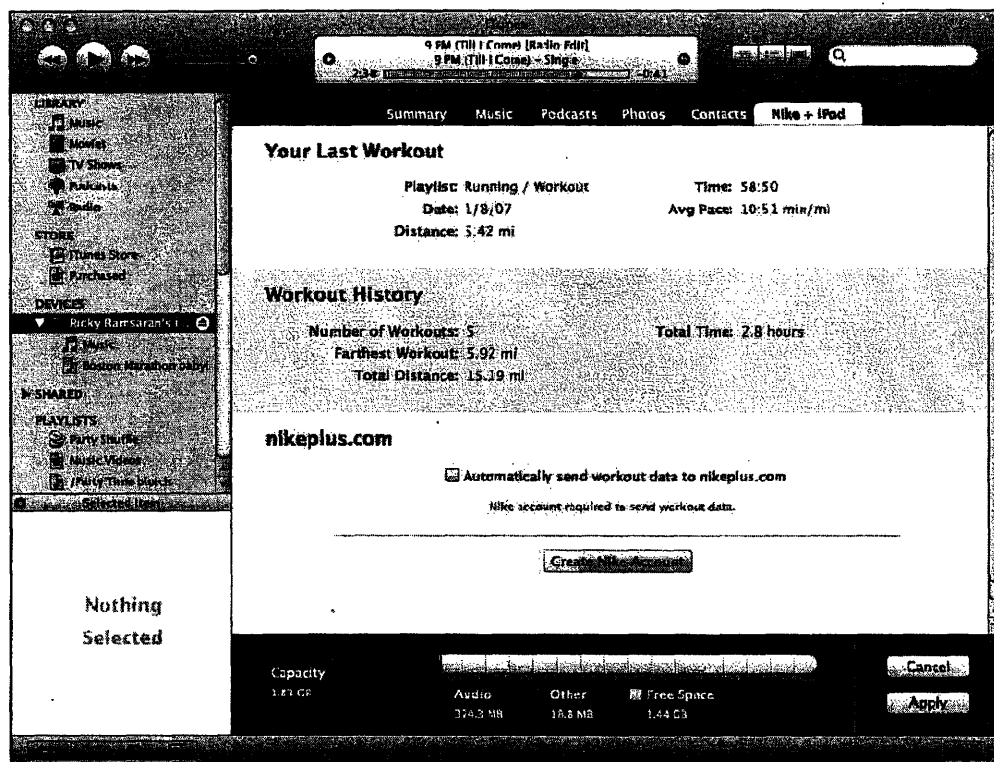


Figure 4: Nike+ Display
www.nikeplus.com

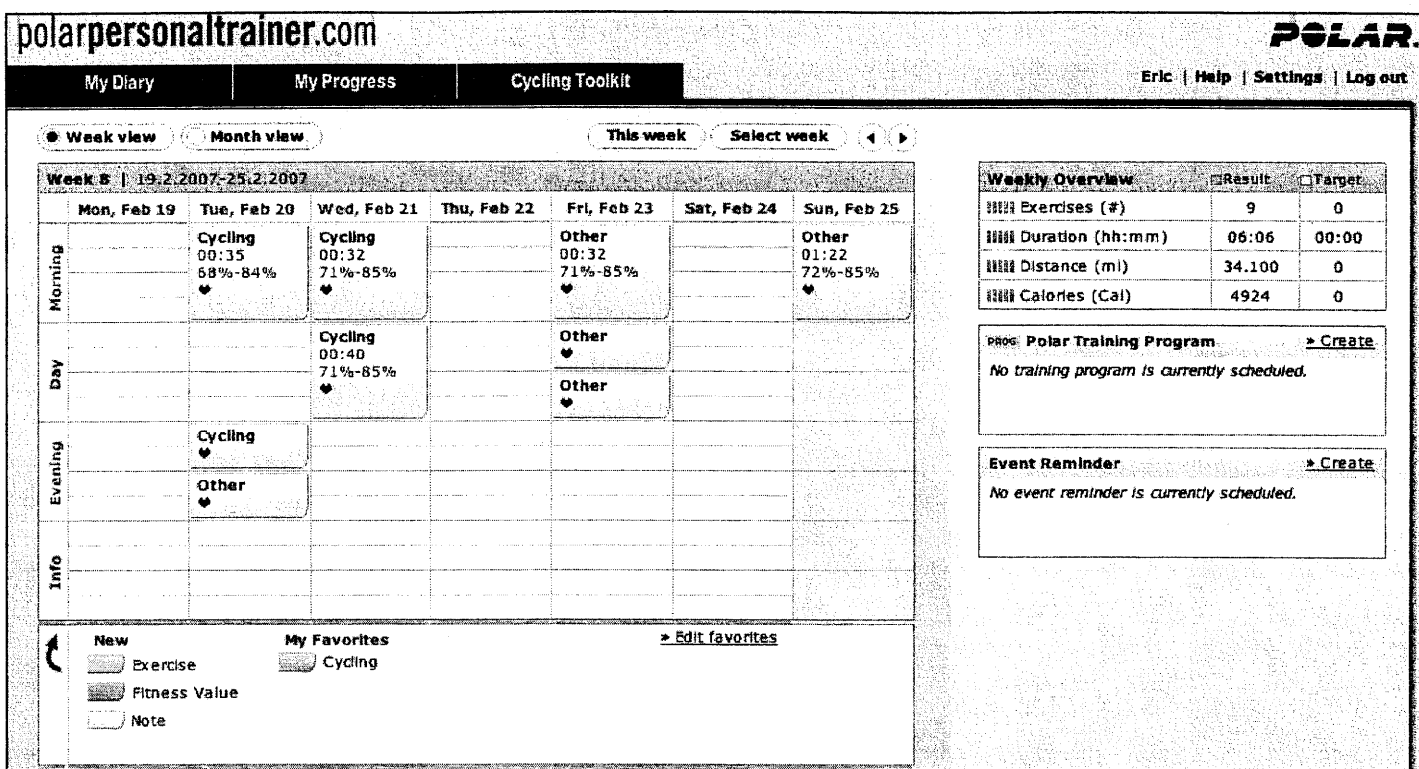


Figure 5: Polar Personal Trainer Display
www.polarpersonaltrainer.com

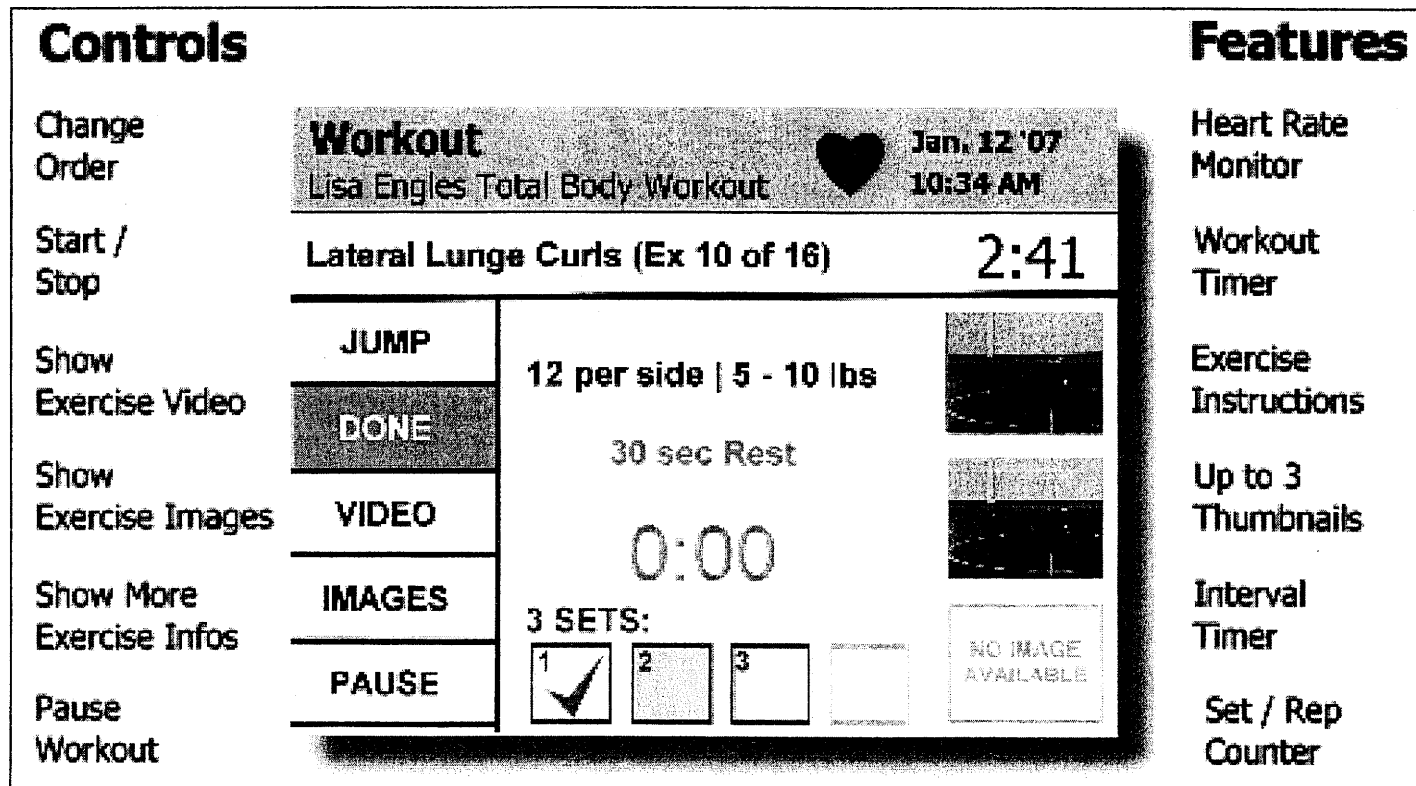


Figure 6: Progio Training Companion Display
www.progio.com

Unresolved Issues

Several issues persist to be unaddressed, mainly the details of the sensors, cost and power consumption. The latter also does not allow us to make proper battery lifetime calculations. The current location of the sensors are also in question and though they are in the generally appropriate locations, it will be necessary to evaluate whether these are the ideal locations.

Conclusion/Lessons

This project, developing the next “wow” fitness product, went through the entire design process; conducting extensive research, discovering needs within the fitness community, conceptualizing solutions, systematically narrowing solutions, and finally fully conceptualizing a product in the sensor gloves. As expected, beginning such an endeavor at the beginning stages and attempting to go through the entire design process in a short time frame (four months), was not possible, and a tangible sample is yet to come. With that in mind, the future individuals continuing this project have a solid foundation in the work done, not only for carrying this product through to completion, but also for various other addressable problems in the industry. In the process various useful information websites and various obscure industry products were found that have been accumulated in Appendixes D, E, and F, and will serve as a good resource and basis for future research and product development addressing fitness community needs.

Along with the direct work, various important lessons were learned that should serve as a take away message. First, whatever you can conceptualize has often already been thought of by others, and if it is truly an ingenious idea, it either already exists or is in production. Out of our final eight ideas, one turned out to already be a fully functional product (Reebok Deck), and two were released within the last four weeks of the project (Precor AMT and Life Fitness Resistance Vest). With that said, the designer should not become discouraged and give up, but rather take this fact as a challenge to not only be more creative but also to seek out the currently existing technologies and learn from them. The second take away message of this project has been that in product design, front loading is essential. Especially within our procrastinate society, there is an important

place for proactivity and initiative. Unexpected problems will arise further down the pipeline that will require extensive troubleshooting, but a substantial portion of these issues can be counteracted by front loading. It would be a large waste to spend great lengths developing a product and realize that it already exists, is fundamentally flawed, or is not mass manufacturable. As a designer one should go to great lengths to prevent these occurrences; “start early and start often”. Finally, the design process is in existence for a reason; it is an effective method of developing new products and should be carried out in full. “Taking short cuts is a false economy and will cost you greatly in the end.” (Doug Vincent, CEO of DesignMentor) If done properly, however, great ideas do become great realities that become great successes within their given industry.

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Benjamin Linder
Design for Demining Instructor

David Wallace
Product Engineering Processes Instructor

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2. World Health Organization, "Obesity and overweight", 2007, <www.who.int/dietphysicalactivity/publications/facts/obesity/en> (10 May 2007)
3. Life Fitness, "Benefits of Exercise", 2005, <http://us.commercial.lifefitness.com/content.cfm/benefitsofexercise_2>, (10 May 2007)
4. Life Fitness, "Flexible Benefits", 2005, <http://us.commercial.lifefitness.com/content.cfm/flexiblebenefits_2>, (10 May 2007)
5. Amby Burfoot, "Everybody knows...", 2007, <www.runnersworld.com/article/0,7120,s6-241-287--7001-0,00.html>, (10 May 2007)
6. Centers for Disease Control. "About BMI for Adults", 26 Aug 2006, <www.cdc.gov/nccdphp/dnpa/bmi/adult_BMI/about_adult_BMI.htm> (10 May 2007)
7. Brian Mackenzie, "Conditioning", 2 Apr 2007, <www.brianmac.demon.co.uk/conditon.htm>, (10 May 2007)
8. "Fitness Components", <www.exrx.net/ExInfo/FitnessComponents.html>, (10 May 2007)
9. Greg Welk & Ron Hager, "Concept 11: Muscle Fitness", <www.mhhe.com/hper/physed/clw/webreview/web11/sld004.htm>, (10 May 2007)
10. Steve G. Steinberg, "Taming the Exponential", <www.steinberg.org/copy/opinion7.html>, (10 May 2007)
11. Michael R. Douglass, "Development of the Digital Micromirror Device", 7 Sep 2005, <www.dlp.com/tech/research.aspx>, (10 May 2007)
12. "Brainstorming", 4 May 2007, <<http://en.wikipedia.org/wiki/Brainstorming>> (10 May 2007)
13. Seyyed Khandani, "Engineering Design Process", Aug 2005, <www.iisme.org/etp/HS%20Engineering-%20Engineering.pdf> (10 May 2007)

References (2 of 2)

14. Benjamin Linder and Andrew Heafitz, "Design for Demining", May 2007, <web.mit.edu/demining> (10 May 2007)

15. Brian Mackenzie, "Energy Pathways", 10 Mar 2007, <<http://www.brianmac.demon.co.uk/energy.htm>> (10 May 2007)

16. Food and Drug Administration, "Body Mass Index Chart", 12 Mar 2004, <www.fda.gov/hearthealth/lifestyles/chart.html> (10 May 2007)

Appendix Index

A – Concept Sheet for Eight Ideas

B – Original Concepts

C – Cardio Machinery Pictures

D – Industry Companies

E – Relevant Websites

F – Interesting Products

Appendix A

Bench with Strength

- Simplicity
- Higher Platform
- Aerobic Step?
- Water bottle holder (rubber basin)
- Performance Apparel coating (moisture wicking)
- Stretch hole
- Incline/Decline with leg holder (-45 to 90 degrees)
- Bench press add on
- Dip built in (45 degrees off of back)
- Pull-up add on (extend from dip)
- Acrylic finish
- Rollerblade wheels
- Stable at upright position for storage
- Nonmetal structure (carbon fiber, acrylic, polycarbonate)
- Mirror finish
- Mirror on rear
- Resistance up to 100lbs
- Use common items as resistance
 - Books, rocks, tools (hammer, screwdrivers), subwoofer

Minimized Elliptical

- Attachment Methods
 - Flexures, Snap-Fits, Twist-Fits
 - Friction hold (pen cap), Thumb-bolts
- Telescoping connectors
- Human-powered

3-1 Stepper, Arc, Elliptical

- Pin adjustment switching
- Cam adjustment switching
- Replaceable cams

New Feel Elliptical

- New motion
 - Wider apart (foot gap)
 - Larger range of motion
 - Adjustable range of motion
- Twist motion
- New Look
 - Acrylic, limited metal, stretch platform/bar
- Flywheel
 - Remove/Replace
 - Make denser & smaller
- Add suspension to pedals

Elliptical/Bike with Strength

- Folding Bench
- Pulley system for arms
- Use motor for arm resistance

Treadmill with Strength

- Console can play music out of speakers
- Rigid mast and support (can do dips)
- Hook to hang towel
- Bench off the front
- Fly machine
- Stretch bar
- Lower back row machine
- Sprint mode (free spin track)
- Mirrored front of front panel
- Bench press in the treadmill

Resistance Vest

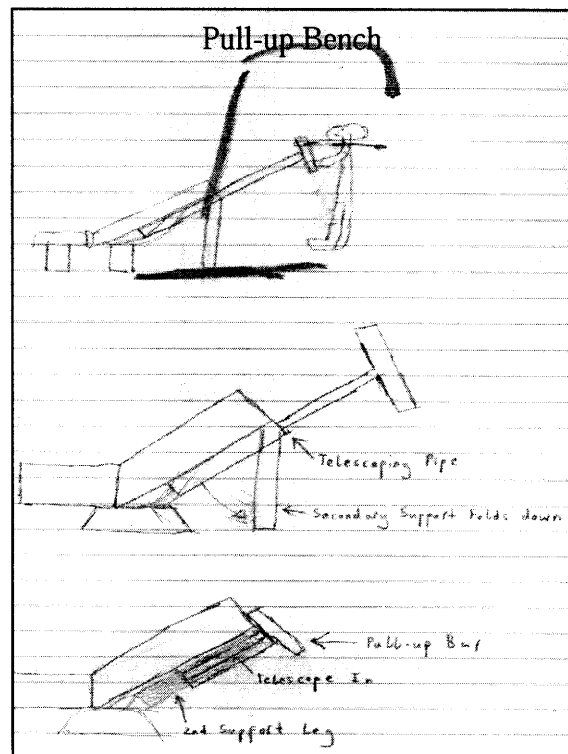
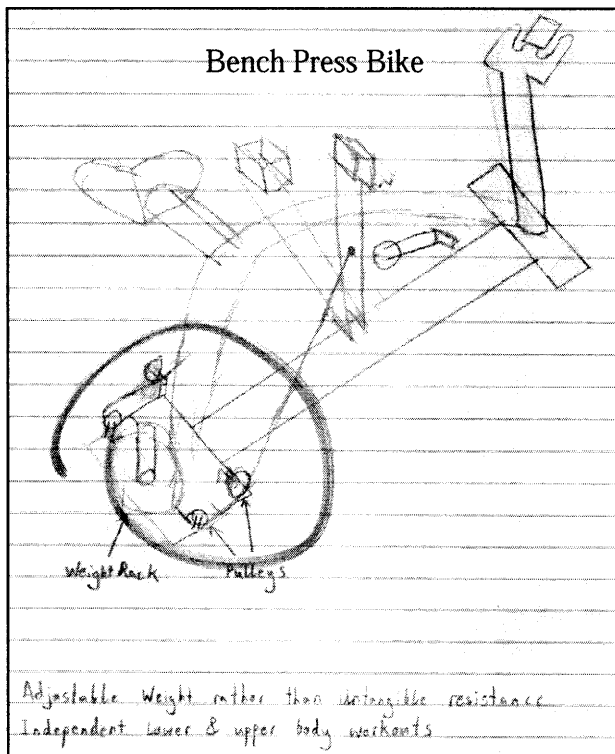
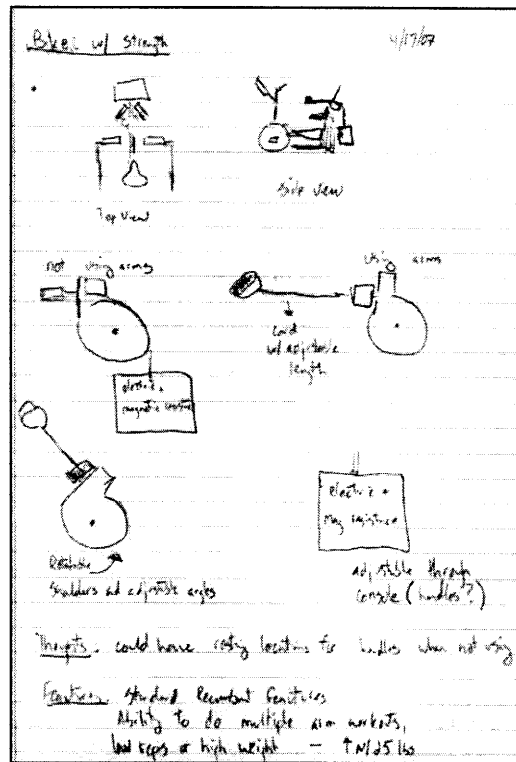
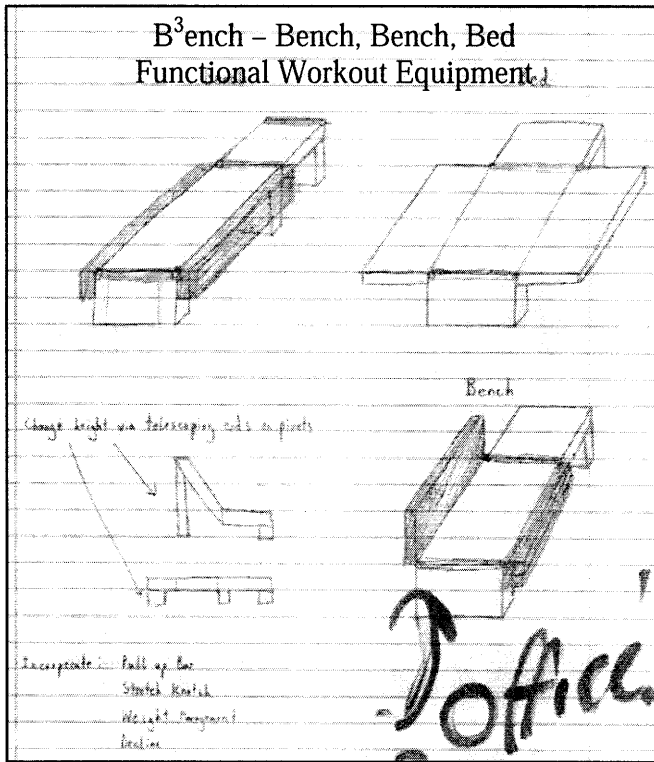
- Possibly a weighted vest. (variable weights)
- Clips in various locations
- Bicep curls, triceps pull down, chest press, taebo motion
- Lateral raises forward and to the sides
- Fits under a jacket
- Can run in (arm motion workout)
- Multiple attachment points
- Heavy stitching
- Performance apparel material
- Machine washable
- Water proof (swimming)?
- Adjustable vest weight (0-10lbs)
- Adjustable resistance (0-25lbs)
- Standard handles
- Attached handles (vasa trainer like)
- Motions:
 - Free fighting strikes (jab, cross, hook, uppercut)
 - Press, flys, tricep extension, bicep curl, ab crunch, side bend

Sensor Gloves

- RFID
- Work in tandem with strength machines
- Machine is the intelligent part
- Performance Apparel Material
- Fit (Elastic, Velcro, Drawstring)
- iPod Sync
- Small Display
- Info
 - Reps, Sets Exercise

Figure A1: Concept sheet for eight ideas

Appendix B (1 of 4)

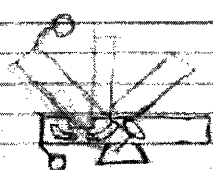


Appendix B (2 of 4)



Complexity is key
 Simplified products in past haven't worked
 Need heavy feel
 Too simple not cool

Super Bench


Features: Water bottle holder
 No pulling
 Stacked platform
 Weight management system
 Incline/Decline of leg holder
 Back press roll on
 Acrylic Finish
 Wheels
 Upright position for things
 Inexpensive
 Rear Mirror
 Entire in height



use tension band at 2 or 3rd pt. Weight could be on seating part

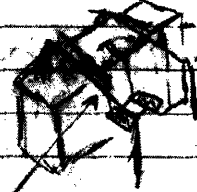



Spinning Bike w/ Rocky Axis



Bike Rocks 0°
 $\sim 0 \leq 5^\circ$

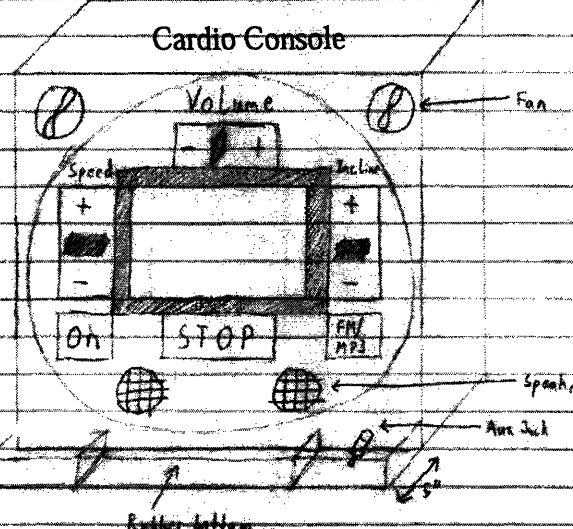
Magd Ski Machine / "Stepper"



Side-to-side
 and up-and-down freedom

arm handles + supports

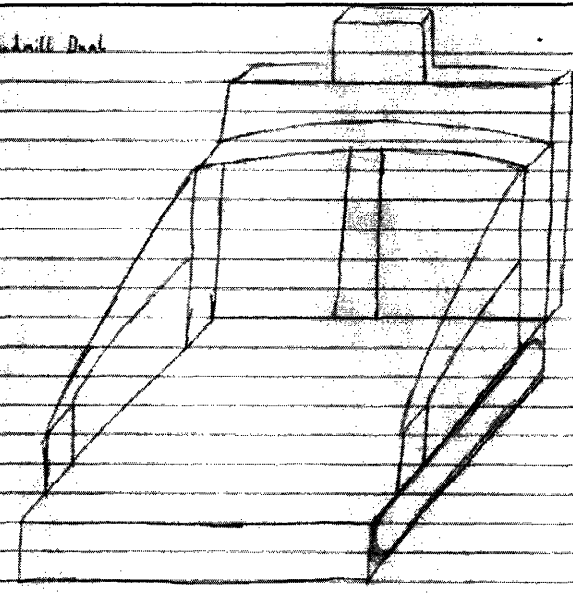
Cardio Console



2" ↑
 Rubber bottom
 5°

2 Mist Fans
 2 Speakers (20W/channel) - Soundbar Quality/Strength
 Acrylic Trim
 Large Jog Switches/Buttons/"Volume" Wheels

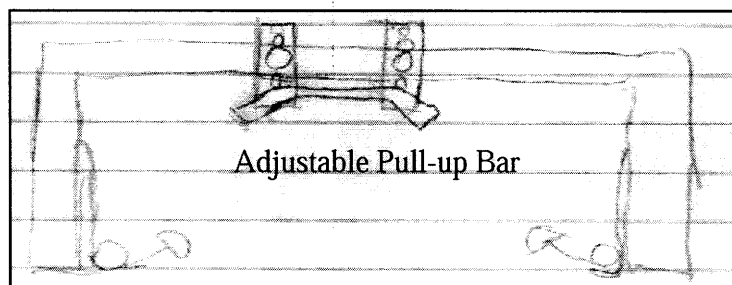
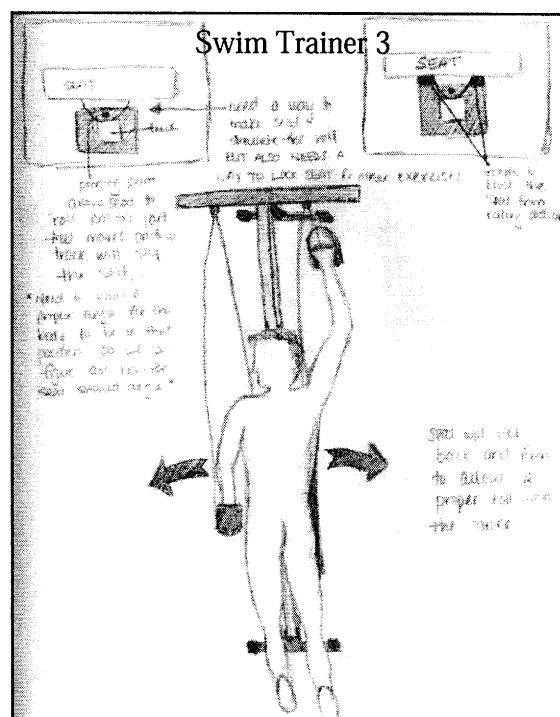
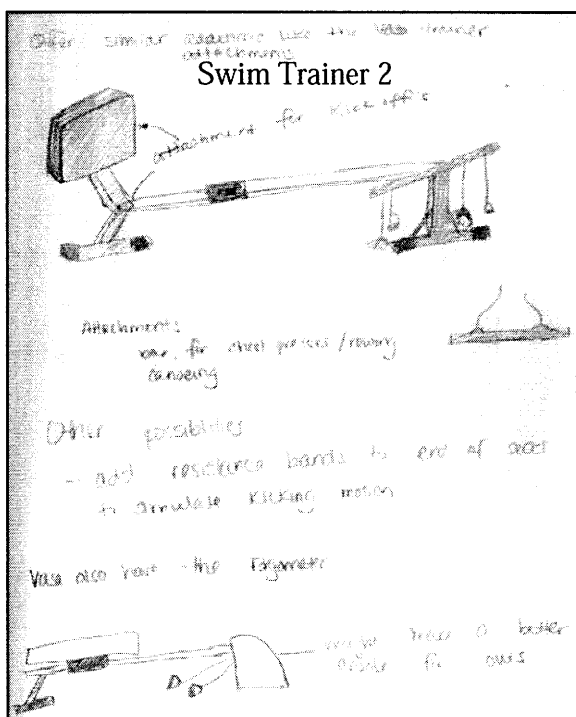
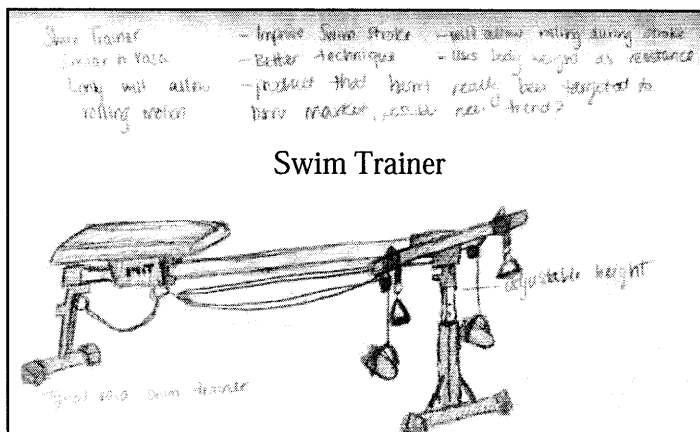
Treadmill Dual



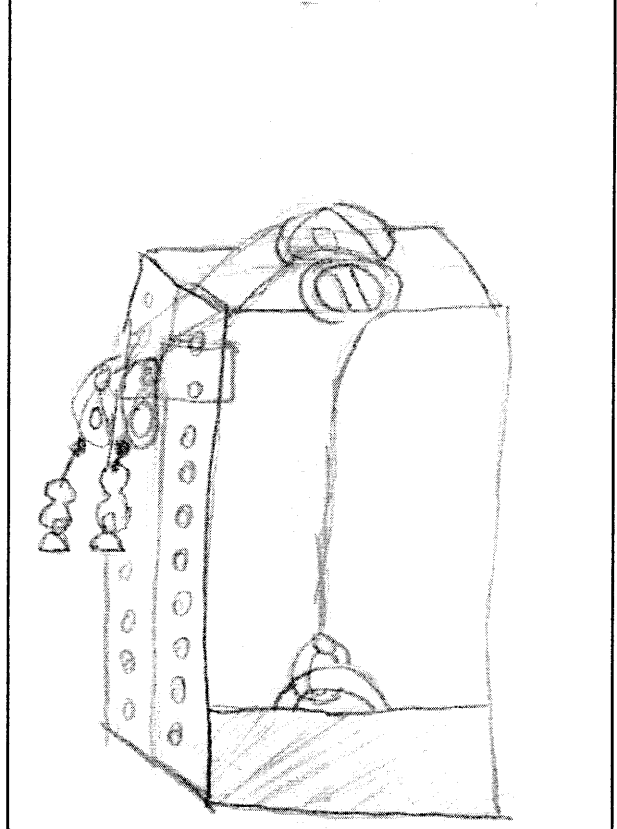
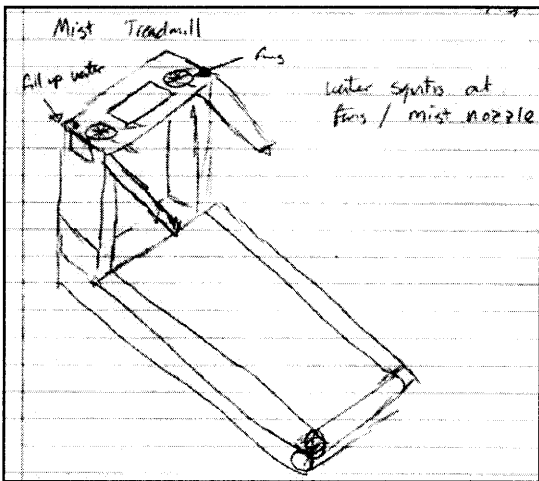
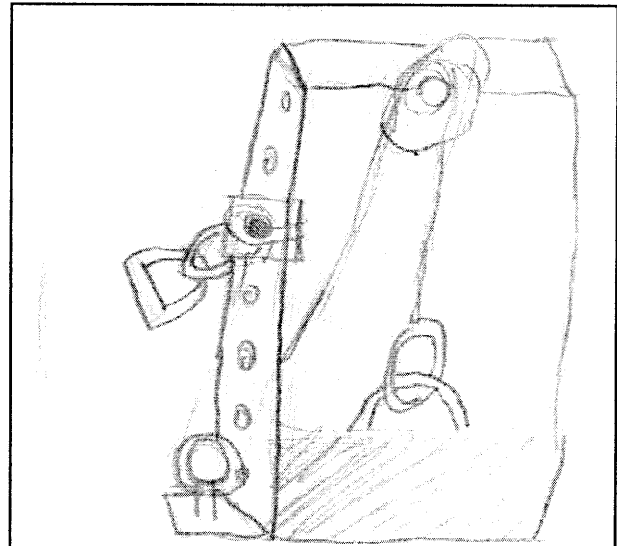
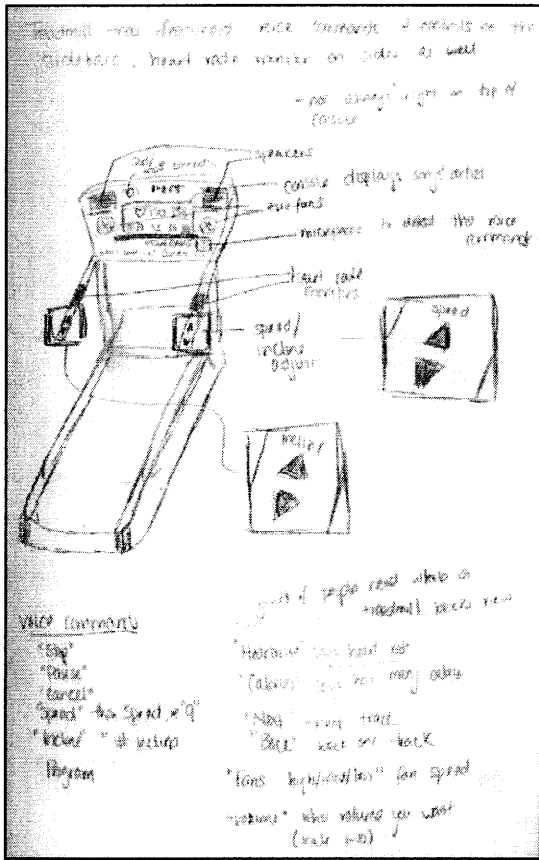
Motor: 6HP
 0 to 12 mph
 0 to 15° Incline

Common Training
 2 person hold
 Finish Acrylic painting

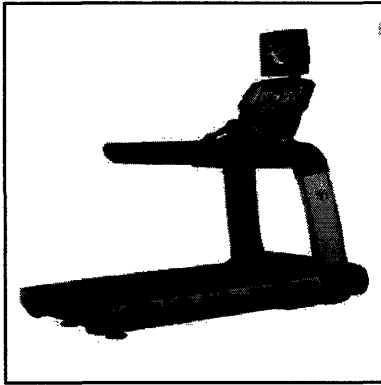
Appendix B (3 of 4)



Appendix B (4 of 4)



Appendix C (1 of 2)



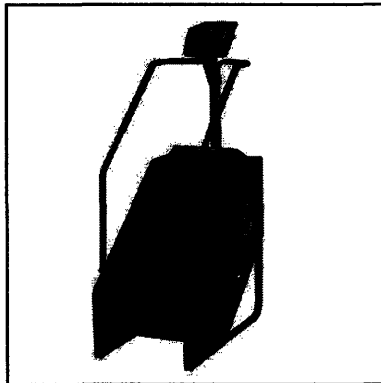
Life Fitness Treadmill 95Ti



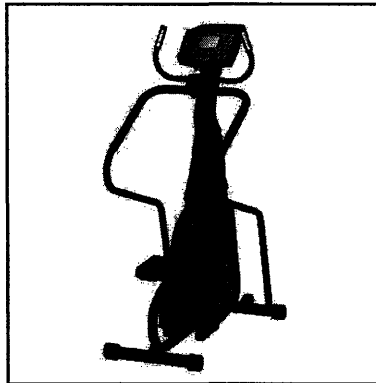
Life Fitness Lifecycle Exercise Bike 95Ce



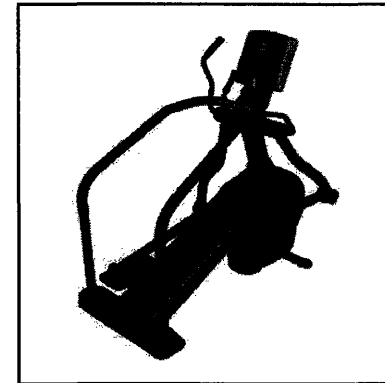
Life Fitness Lifecycle Recumbent Exercise Bike



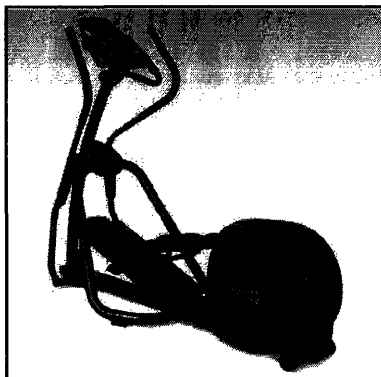
StairMaster StepMill 7000PT



StairMaster FreeClimber 4600PT Exercise System



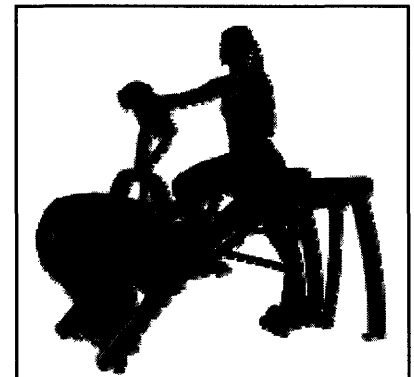
Life Fitness Summit Trainer 95Le



Precor Elliptical Crosstrainer EFX 5.33 (Rear Flywheel)



Horizon Fitness Elliptical 4.3E (Front Flywheel)



Cybex Self Powered Arc Trainer

Appendix C (2 of 2)



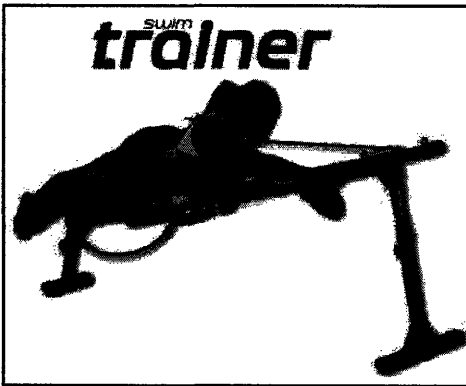
Nautilus TreadClimber TC 916



TechnoGym Cardio Wave 700iE



Precor AMT
(Adaptive Movement Technology)



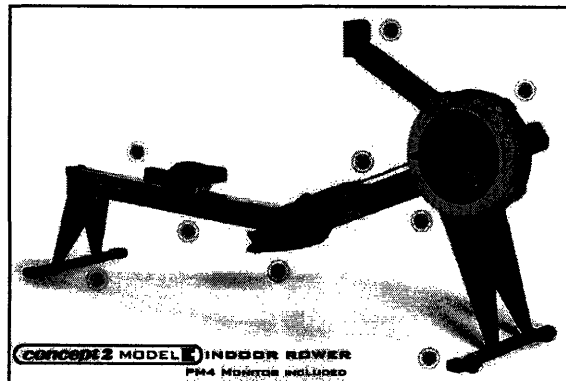
Vasa Trainer



Vasa Ergometer



Vasa Kayak Ergometer



Concept2 Model E Indoor Rower

Appendix D (1 of 2)

Major Companies:

<i>Home</i>	
Horizon Fitness	www.horizonfitness.com
Icon Fitness	www.iconfitness.com
New Balance	www.newbalancefitness.com
Nordictrack	www.nordictrack.com
Pro-Form	www.proform.com
Sportcraft	www.sportcraft.com
Weslo	www.weslo.com
<i>Commercial</i>	
Cybex	www.cybexinternational.com
Life Fitness	www.lifefitness.com
Precor	www.precor.com

<i>Specialty</i>	
Landice	www.landice.com
True Fitness	www.truefitness.com
Vision Fitness	www.visionfitness.com
<i>Accessories</i>	
Gaiam	www.gaiam.com
Go Fit	www.gofit.net
<i>Heart Rate Monitors</i>	
Polar	www.polarusa.com
Sportline	www.sportline.com

Suppliers:

Big Fitness	www.bigfitness.com
Fitness Factory	www.fitnessfactory.com
Fitness Giant	www.fitnessgiant.com
Fitness Quest	www.fitnessquest.com
Health Styles	www.healthstyleexercise.com
Perform Better	www.performbetter.com

Infomercials:

www.asseenontvnetwork.com
www.fitnessinfomercialreview.com

Fitness Equipment Reviews:

www.fitness-events.com
--

Sporting Associations:

Sporting Goods Manufacturers Association	www.sgma.com
Sports Business Research Network	www.sbrnet.com

Appendix D (2 of 2)

Other Companies:

<i>Normal</i>	
Amer Sports	www.amersports.com
Apex Fitness	www.islandnet.com/~apex
Bowflex	www.bowflex.com
Concept2 Rowers	www.concept2.com
HUR Fitness	www.hur.fi
Koko Fitness	www.kokofitness.com
Nautilus	www.nautilusinc.com
Octane Fitness	www.octanefitness.com
Paramount Fitness	www.paramountfitness.com
Reebok Fitness	www.rbkdirect.co.uk
Smooth Fitness	www.smoothfitness.com
Sole Fitness	www.soletreadmill.com
Star Trac	www.startracusa.com
TechnoGym	www.technogymusa.com
Tunturi Fitness	www.tunturi.com
Vasa Trainer	www.vasatrainer.com
<i>Hydraulic Fitness Equipment</i>	
Cole Circuit Solutions	www.colecircuitsolutions.com
Edge Fitness	www.edgefitnessmfg.com
Fast Fun Fitness	www.fastfunfitness.com
Fit Express	www.fitexpress.com
HFitCo	www.hfitco.com
Hydracise	www.hydracise.com
Shape for Women	www.shapesforwomen.com
<i>Weight Vests</i>	
Xvest	www.thexvest.com
Xtreme Athletic Equipment	www.xtreme-athletic-equipment.com

Magazines:

Men's

Fitness Online	www.fitnessonline.com
Flex	www.flexonline.com
Men's Fitness	www.mensfitnes.com
Men's Health	www.menshealth.com
Muscle & Fitness	www.muscleandfitness.com

Women's

Fitness	www.fitnessmagazine.com
Oxygen	www.oxygenmag.com
Self	www.self.com
Shape	www.shape.com
Weight Watcher	www.weightwatchers.com
Women's Health	www.womenshealthmag.com

Appendix E (1 of 3)

Design Websites:

Product Design Process/Specifications:
http://ider.herts.ac.uk/school/courseware/design/pds/example.html
http://ider.herts.ac.uk/school/courseware/design/overview/overview.html
www.micron.com/students/engineer/design.html
www.iisme.org/etp/HS%20Engineering-%20Engineering.pdf
www.bergen.org/technology/despro.html
www.stopdesign.com/articles/design_process/
Brainstorming:
http://en.wikipedia.org/wiki/Brainstorming
Creative Thinking:
http://quality.dlsu.edu.ph/tools/creativity_tools.html
www.mycoted.com
www.newandimproved.com
Mechanisms:
http://kmoddl.library.cornell.edu

Fitness Knowledge Websites:

Exercise Knowledge	
City Sports	www.citysports.com/infohome
Fitness Files	http://tms.ecol.net/fitness
Government Fitness	www.fitness.gov
How Stuff Works	health.howstuffworks.com/sports-physiology.htm
Life Fitness	http://us.commercial.lifefitness.com/content.cfm/researcharticles
MedBio	www.medbio.info
Nautilus Institute	www.nautilusinstitute.org
Precor	www.precor.com/comm/tools/research
Sports Coach	www.brianmac.demon.co.uk
Training & Physiology Q&A	http://home.hia.no/~stephens/qanda.htm

Appendix E (2 of 3)

Fitness Websites:

Fitness History:	www.unm.edu/~lkravitz/Article%20folder/history.html
Treadmill History:	www.treadmill-online.com www.thehistoryof.net/history-of-treadmills.html
Elliptical Trainer History:	www.precor.com/comm/en/story/efx/?p_rtnURL www.thehistoryof.net/history-of-ellipticals.html
Fitness Glossary:	www.precor.com/comm/tools/glossary
General Health & Fitness:	www.primusweb.com/fitnesspartner/index.html www.sleepfoundation.org
Skill Fitness Component:	www.brianmac.demon.co.uk/conditon.htm www.exrx.net/ExInfo/FitnessComponents.html www.fitness.gov/digest_mar2000.htm
Stretching:	http://us.commercial.lifefitness.com/content.cfm/flexiblebenefits_2 www.runnersworld.com/article/0,7120,s6-241-287--7001-0,00.html
Heart Rate:	http://home.hia.no/~stephens/qanda2.htm
BMI:	http://tms.ecol.net/fitness www.cdc.gov/nccdphp/dnpa/bmi/adult_BMI/about_adult_BMI.htm www.fda.gov/hearthealth/lifestyles/chart.html www.findarticles.com/p/articles/mi_m0NAH/is_8_33/ai_108785995 www.exrx.net/ExInfo/FitnessComponents.html
Calories Intake:	http://health.howstuffworks.com/question457.htm www.primusweb.com/fitnesspartner/library/weight/calsburned.htm www.primusweb.com/fitnesspartner/jumpsite/calculat.htm
Obesity:	www.cdc.gov/nccdphp/dnpa/obesity/economic_consequences.htm www.healthgoods.com www.who.int/dietphysicalactivity/publications/facts/obesity/en www.kidshealth.org/parent/nutrition_fit/nutrition/overweight_obesity.html
Muscle versus Fat:	http://sportsmedicine.about.com/cs/body_comp/a/aa012599a.htm http://answers.google.com/answers/threadview?id=576481
Women & Weight Training:	http://us.commercial.lifefitness.com/content.cfm/whywomenneedtoweighttrain_2 www.bioforcetnt.com/scripts/cgiip.exe/WService=bf/story.html?article=3094 www.precor.com/pdf/women_weight_ENGLISH.pdf

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Research Websites:

Biomechanics Articles:	http://us.home.lifefitness.com/content.cfm/biomechanics
	http://us.commercial.lifefitness.com/content.cfm/researcharticles
	http://club.octanefitness.com/research/index.cfm?PAGE_ID=33
	www.ellipticaltrainers.com/articles/elliptical_articles.htm
	www.ellipticaltrainers.com/articles/elliptical_treadmill.htm
	www.runningforums.com/Running_v_Elliptical_Trainer_t12607.html
Biomechanics Institutes:	http://isbweb.org/o/content/view/38/56
	www.humankinetics.com/JAB/journalAbout.cfm
	www.asbweb.org
	www.anzsb.asn.au
	www.esbiomech.org
Sensors:	www.motionanalysis.com
	www.emfit.com
	www.vtt.fi
Electro-Tectiles:	www.fibretronic.com
	www.textronicsinc.com
Electromagnetic Resistance:	www.tunturi.com/fitness/brake.cfm
	www.patentstorm.us/patents/6224519-fulltext.html
	www.freepatentsonline.com/6224519.html
	www.freepatentsonline.com/4765613.html
Sports-Injury Anatomy:	www.kylepalmermd.com/

Appendix F

Interesting Products:

<i>Relevant</i>	
ActiPed	www.fitsense.com
Polar F55	www.polarusa.com
Progio	www.progio.com
Training Vest	www.lifefitness.com

<i>Other Specialty</i>	
BalanceBall Chair	www.gaiam.com
Clubbell	www.rmaxinternational.com
Gripmaster	www.rbkdirect.co.uk
Hydracoach	www.hydracoach.com
Power Hooks	www.powerhooks.com
Power Plate	www.performbetter.com
Reebok Deck	www.reebokdeck.com
Reebok Step	www.rbkdirect.co.uk
Vertec	www.performbetter.com
LifeSpan Stretch Partner	www.gaiam.com
Precor StretchTrainer C240i	www.precor.com
Truestretch Stretch Station	www.performbetter.com

<i>Other Cardio</i>	
Gazelle	www.tonylittle.com
HealthRider	www.healthrider.com
i-run Treadmill	www.rbkdirect.co.uk
Manual InMotion Treadmill	www.gaiam.com
NordicTrack Classic Pro Skier	www.nordictrack.com
NordicTrack X10 Incline Trainer	www.nordictrack.com
Pro-Fitter	www.performbetter.com
ROM Time Machine	www.fastexercise.com
Slideboard	www.performbetter.com
True Fitness TS1 True Strider	www.truefitness.com
Versa Climber	www.versaclimber.com
<i>Other Strength</i>	
Bio Force TNT System	www.fitnessquest.com
Body Blade	www.bodyblade.com
Body Solid Bicep Bomber	www.bigfitness.com/bosobibo.html
BowFlex SelectTech 5.1 Bench	www.bowflexselecttech.com
PlateMate Weight Magnets	www.performbetter.com
Power Pushup 2	www.qfac.com/gear/ppu2.html
Total Gym	www.totalgymdirect.com