

Guts Barbell: An AI-Driven Mobile Fitness Application for Hypertrophy Training, Culturally Adaptive Meal Planning, and Personalized Content Generation

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Abstract

We can see a pattern of growth in Fitness technology over recent years, but most available applications still seem to fall short because they treat everyone the same. In almost every context like food they are supposed to eat or the training regime they are supposed to follow their geographical vicinity doesn't account their general diet doesn't matter their progress is also neglected and their goals are not taken in consideration. The solution we came up with GUTS BARBELL is a proposed mobile fitness application. It is organized around three modules that work together the first one is a meal planning engine that draws from the user's nationality and regional food culture to make daily meal plans suitable for their body and goal. Second a hypertrophy program generator that based on the user's preferences makes optimal training programs considering how long they have been working out. Third A blog system that generates fitness content based on the user's interests. This paper shows the foundation, system architecture, and technical approach for making GUTS BARBELL, based on established research from exercise science. The aim is to make a science based lifting application that can provide credible research based information to everyone.

Keywords: Hypertrophy training, nutrition planning, science based lifting application, culturally adaptive meal planning, natural language generation, resistance training, exercise science.

1. Introduction

1.1 Background and Motivation

Fitness applications seem to have become a significant part of how people manage their health, and the numbers show that picture. Global fitness app revenue was around USD 15.8 billion in 2023 and the market projected to exceed USD 33 billion by 2030 which is a gross estimate. But still despite all this growth we see a frustrating pattern. What these apps generally offer is old redundant and even faulty potentially harmful information for the most part. They hand

every user the same programs and same dietary advice not considering their background at all geographically or genetically where the person comes from

Building muscle or muscle hypertrophy is a process that requires things like realistic goal setting and consistency. Every individual should train based on their current strength and recovery capacity no matter how small they start the goal is to slowly keep building. The food they are prescribed should account not only the macros and micros but their general eating patterns. Existing applications are seldom solving this problem and so we decided to do so.

Lets take a simple example a university student does not have a plethora of food options to their display atleast in india so they have to take a path of nutrition that is easier on the pocket and also local for the most part it should include things like dal, chawal, paneer, eggs soyabean things that are readily available and are cheap and not things like tofu or tuna which arent part of a staple indian diet

GUTS BARBELL was designed with these parameters in mind. Rather than just applying a regular template, the application builds its recommendations based on the users input and not the other way around

1.2 Problem Statement

Three main problems motivate the design of GUTS BARBELL:

Meal planning being the first in existing fitness apps the meal planning mostly relies on generic dietary templates that don't consider the user's regional eating habits or locally available foods, or cultural norms. Which results in people just failing to plan their meals.

Training programs is the second thing that motivated us to make GUTS BARBELL current applications don't really adjust to a user's actual strength, training experience, or recovery capacity. Programs are either too easy for experienced users or just too difficult for beginners, and neither group is served.

Educational fitness is the Third main pillar of our application in general the content within applications is static or generic. It does not evolve with the user's interests or progress, and it almost never delivers the kind of information that generate interest.

1.3 Research Objectives

The main goal of our research is to accomplish the following:

Making a mobile application that contains three modules for meal planning, hypertrophy programming, and generating content.

Build a culturally adaptive nutrition planning framework that uses nationality and regional data to generate macronutrient-aligned meal plans from foods the user already recognizes and eats.

Develop a culture-sensitive nutrition planning system that uses student's data on nationality and region to create macronutrient-balanced meal plans from the foods they are familiar with.

Create a scientifically-validated hypertrophy program generator that makes exercise prescriptions based on the user's performance metrics and implements progressive overload over time.

Create a natural language generator that generates high-quality and interest-specific fitness blog articles for each user.

Compare proposed solution to the current state of the art in fitness apps in terms of personalization, customization and scientific rigor.

1.4 Scope and Limitations

This work includes the conceptual, theoretical and architectural design of GUTS BARBELL. Details of the three major components - diet planning, program generation and blog content - are given. The paper does not address clinical trial and longitudinal studies to show efficacy; these are the planned focus of subsequent research. Technical

details are provided at the prototype and design specification level, with large-scale implementation to come in future development.

2. Literature Review

2.1 Exercise Science and Hypertrophy

Our knowledge of muscle hypertrophy has improved markedly over the last three decades. Various studies have identified three main mechanisms by which resistance training stimulates muscle hypertrophy: mechanical tension (heavy loads), metabolic stress (high repetitions) and muscle damage (eccentric contractions). In recent studies, muscle tension - especially when the muscle is stretched - has been shown to be the most important contributor to myofibrillar hypertrophy.

Training volume, measured in terms of the number of sets performed per muscle group per week, is the best-supported dose-response variable in the context of hypertrophy. Several meta-analyses have verified a significant benefit of higher training volume over single-set training, and a weekly prescription of around 10 to 20 sets per muscle group is a safe, practical and effective dose for intermediate trainees.

Periodization, or the manipulation of training load and volume over time, is also critical for continued gains in the intermediate- to advanced-training stage. Both linear periodization (systematic advancement of load within weeks) and undulating periodization (load and volume fluctuations within sessions) have been shown to be effective in experimental studies. GUTS BARBELL's program generator uses both approaches to generate programs, depending on the trainee's prior training experience.

A particularly practical framework is that of Israetel, Hoffman and Smith who suggested that weekly volume prescriptions be classified into four thresholds: Maintenance Volume (MV), Minimum Effective Volume (MEV), Maximum Adaptive Volume (MAV) and Maximum Recoverable Volume (MRV). This is a simple and practical framework for program design to modulate volume based on individual recovery capacity, and the model underpinning GUTS BARBELL's hypertrophy program.

2.2 Nutrition Science and Meal Planning

Hypertrophy can't take place in a nutritional vacuum. A positive energy balance above total daily energy expenditure (TDEE) is required to shift the balance in favour of net muscle protein synthesis. For lean muscle development, the recommended surplus is typically 200-500 kilocalories per day, with the actual surplus depending on the trainee's level of experience, body composition, and amount of fat gain that can be tolerated.

Protein is the most researched and most important nutrient for hypertrophy. A recent meta-analysis found protein intakes of about 1.62 grams per kilogram of body weight per day optimally stimulate muscle protein synthesis in resistance-trained subjects. Splitting this protein intake between four to six meals containing about 0.4 grams per kilogram of body weight keeps muscle protein balance positive throughout the day.

Less known in the literature, however, is the influence of cultural food environment on dietary compliance in sports. The past decade of dietary adherence literature has shown that when recommendations fit one's cultural food preferences, dietary compliance is higher. For example, for the Indian population, lentils, cottage cheese, whole grains and legumes are some of the staple foods that can be consumed to provide hypertrophy-specific macronutrient goals (with appropriate portion sizes). GUTS BARBELL's meal generator takes this evidence into account by connecting geographic user data to culturally-annotated food databases, to ensure that the recommendations are both nutritionally sound and usable.

2.3 AI in Fitness Applications

The application of machine learning and AI in health and fitness has increased significantly in recent years, as a result of large language models and inference hosting platforms. According to a review of AI-powered health applications, the most common features of these apps were the personalisation of exercise recommendations, dietary analysis and behaviour nudging. However, the review also found less than 15% of the apps reviewed used verified exercise science principles in their recommendation algorithms - a worrying disconnect between technology and science.

Reinforcement learning has successfully been applied to dynamic exercise prescription in research. A recent study found that an RL agent trained to respond to adherence and performance feedback was able to better prescribe changes to training load than traditional progressive overload training. Collaborative filtering has been applied to workout recommendation systems, but there is a lack of published literature on its application for hypertrophy-specific workouts.

Large language models such as GPT-4 and similar models have been demonstrated to have strong performance for generating health content, helping with diet planning and coaching for exercise. GUTS BARBELL plans to harness this potential in its blog generator and use domain-specific prompting to ensure safe and accurate blog posts.

2.4 Personalized Content Generation

Personalization of digital media content has shifted the way we consume media content, and the same applies to fitness content. Collaborative filtering methods developed for entertainment media have been applied (with mixed results) to fitness content. A study of content-aware collaborative filtering for fitness platforms has shown that fitness content with similar interests has greater engagement than the more popular content, which highlights the need for more than trends when personalizing content.

Neural language models such as transformers have shown human-level quality in domain-specific content generation such as medical education materials, scientific abstracts and educational articles. The potential for applying such models to fitness content is to create a system that can generate fresh, accurate and personalised educational content, beyond the scale of traditional editorial control.

3. Our System: GUTS BARBELL

3.1 Architecture

GUTS BARBELL is a cross-platform mobile app with a microservices back-end. The three main parts of the app - meal planner, program generator and blog - are separate services that share user data via a profile layer, enabling personalisation across the three services. The three services are exposed to a single React Native front-end via a Node.js API gateway.

The architecture includes a React Native mobile app, a Node.js API gateway for authentication and request dispatching, three microservices (Meal Planner, Program Generator and Blog Generator), a relational PostgreSQL database (for structured content and user data), a Redis cache (for user sessions), and an OpenAI API layer (for language model capabilities).

On initial setup, the user is prompted to enter their name, age, sex, country, region or state, weight, height, years of training, number of meals per day, main goals for physical fitness and metrics for major compound lifts. This information initialises the three modules and will drive the changes in their outputs as their data changes.

3.2 Module 1: Food Culture-Smart Meal Plan Generator

3.2.1 Conceptual Framework

The meal planning engine simultaneously provides meal plans that are scientifically tuned to the nutritional goals for hypertrophy; and it also relates these plans to the user's food culture. This is done in three steps: (1) calculating the user's total daily energy expenditure (TDEE) (2) determining macronutrient targets and (3) then constructing meals by searching a database of foods from the user's region.

3.2.2 TDEE Calculation

The Mifflin-St Jeor equation is used to calculate Basal Metabolic Rate, as it is considered the best formula to calculate BMR for non-athletic adults, and offers a good starting point for people with a wide variety of body compositions:

$$\text{BMR (men)} = (10 \times \text{weight in kg}) + (6.25 \times \text{height in cm}) - (5 \times \text{age}) + 5$$

$$\text{BMR (women)} = (10 \times \text{weight in kg}) + (6.25 \times \text{height in cm}) - (5 \times \text{age}) - 161$$

The BMR is multiplied by an activity factor (based on training frequency) to calculate TDEE at maintenance. To this is added a hypertrophy surplus between 250-350 kilocalories. The lower of the two figures is given to users who want a lean bulk; the higher is given to users who want to bulk up as quickly as possible.

3.2.3 Macronutrient Targets

Sport nutrition macronutrient goals are determined as per consensus guidelines:

Protein: 1.6-2.0 grams per kilogram of body weight, spread over the number of meals preferred by the user throughout the day.

Carbohydrates: 45-60% of total daily energy intake with a priority for complex carbohydrates and fibre sources that align with the user's local diet and preferences.

Fats: 20-35% of total energy intake, with preference given to polyunsaturated fats, if culturally acceptable.

3.2.4 Culturally Categorised Food Database

The database of foods is constructed by associating nationality and regional codes with food databases, categorised by cuisine. For the Indian user, foods are sub-categorised into groups from each of the regions: North Indian foods such as dal, paneer, roti, rice, rajma, chole, and lassi; South Indian foods such as idli, dosa, sambar and coconut based curries; East Indian foods, such as mustard fish curry and panta bhat; and West Indian foods, such as dhokla, thepla, poha, and other similar foods. The database uses the Indian Food Composition Tables (ICMR-NIN) for the macronutrient component of each food item. The algorithm for meal planning employs the constraint satisfaction method to identify combinations of foods that satisfy the daily protein, carbohydrate and fat goals (within five percent), and also divides protein, carbohydrate and fat intake appropriately across the number of meals the user selects. The archetypal structures for breakfast, lunch, snack and dinner are retained to be culturally acceptable. It produces a rolling seven-day plan to provide a rotating selection of meals.

3.2.5 Special Diets

The engine supports user-specified dietary restrictions such as vegetarian, vegan, lactose and gluten intolerance, as well as halal and kosher. If the restrictions prevent the user meeting their protein needs from whole food foods they are familiar with, supplements are recommended; plant-based protein powder for vegans, for instance.

3.3 Module 2: AI Hypertrophy Program Generator

3.3.1 The Principles of Training underpinning the Module

The program generator creates resistance training programs for the individual based on their current performance and self-reported training patterns. It has a foundation in four principles: progressive overload of load and volume over time; specificity in the choice of exercises to meet the hypertrophic training targets of each muscle group; volume selection awareness of the recovery requirements of the user whose training age and lifestyle variables are considered; and the volume landmark framework of MEV/MAV/MRV that provides the system with a reasonable arena for prescribing weekly sets.

3.3.2 User Performance Assessment

At registration, users enter their one and/or training repetition maximum (1RM and/or TM) for key compound exercises. If users are unable to accurately estimate their 1RM, they are guided through an easy process to estimate their 1RM using the Epley formula, which predicts maximum based on a submaximal set:

$$1RM = \text{Weight} \times (1 + \text{Reps} / 30)$$

Training age is also used to place users into one of three training experience tiers (Novice = zero to 1 year, Intermediate = 1-3 years, Advanced = 3+ years) that are prescribed different volumes and training programs.

3.3.3 Program Structure

Training tier-specific program templates:

Beginner programs are three-day full-body linear periodized. The trainee progresses the weight each week in the major compound lifts (squat, bench press, deadlift, overhead press and barbell row). Volume ranges from MEV to MEV plus two sets per muscle group to keep the stimulus in check while allowing performance improvements.

In intermediate programs, the user will train with a four-day Upper/Lower or Push/Pull/Legs split and undulating periodized training, with workouts ranging from hypertrophy phase (8-12 reps) to strength phase (4-6 reps). Volume is within the MAV.

Advanced programs adopt a five-to-six day Push/Pull/Legs or body part split in a block periodization format, including weeks alternated between accumulation and intensification phases including scheduled deload weeks every four to six weeks. Training volume is close to the upper limit of the MAV.

3.3.4 Auto-selection of Exercises

Our database of movements includes verified primary and accessory movements for each muscle group, tagged with the equipment required, difficulty and risk of injury based on contraindication. The generator automatically selects exercises based on the user's access to barbell, dumbbell, cable, machine or bodyweight equipment and omits exercises if previously flagged for injury risk based on the user's personal injury history. An auto-regulation layer tracks the user's training load (sets and reps) each week. If a user's performance exceeds the target rep range for two consecutive performances with the same load, the system raises the weight by 2.5-5 kg on compound moves or 1-2.5 kg on isolation lifts. If performance declines for two days in a row, the generator flags a likely recovery issue, decreases volume (two sets) and asks the user to record sleep and stress factors to diagnose the issue.

3.4 Module 3: Automatically Generated Fitness Blog

3.4.1 System and Content Strategy

The system for generating blogs uses a large language model via the OpenAI API to create long-form articles on the topic of fitness that users are interested in. User interest profiles are devised in two ways: explicitly from tags users choose when they sign up - powerlifting, bodybuilding, nutrition, recovery, sports science, for example - as well as implicitly from usage patterns: which articles are they reading, which fitness programs are they following, what are they eating? Combined this helps to build an ever deeper profile of user interests.

3.4.2 Prompting and Safety

Content is generated with a domain-specific approach to prompting that ensures every article is grounded in the user's training focus and level of experience, requires the model to adhere to known exercise or nutrition science, prevents the use of non-factual/pseudoscientific language, and requires the article to have a specific structure: introduction, body (containing technical sections), practical sections, references.

A moderation module checks the content generated prior to serving it to the user. It scans for unsafe recommendations and prevents the model from recommending unsafe practices - excessive energy restriction, use of banned substances, or exercise methods that could lead to injury. It flags and regenerates any content that doesn't meet these criteria.

3.4.3 Personalization and Scheduling

We produce new articles each day in five categories: Training Technique, Nutrition Science, Recovery and Sleep, Sports Psychology, and Supplement Reviews. Push notifications are sent to users when new articles in their top priorities for interest categories are published to promote engagement and develop a habit of daily learning for their fitness training.

4. Methodology

Our research adopts a design science research process, a widely-used research method in information systems that considers the designed artefact - in our case the GUTS BARBELL application - as the research product. The approach

includes six steps: problem identification and motivation, definition of the solution objectives, design and development, demonstration, evaluation and communication.

The problem was identified by conducting a systematic review of the fitness application market, complemented with a targeted literature review in the fields of exercise science, nutritional science and AI in health technology from 2010 to 2024. This involved sources obtained from PubMed, IEEE Xplore, ACM Digital Library and Google Scholar, focusing on literature related to hypertrophy training, culturally sensitive nutrition, AI fitness recommendation, and natural language generation of health content.

The solution goals were established by overlapping identified gaps in three areas: nutritional personalisation, intelligent training programs and delivery of content. The system was designed in an iterative review process, with each module's specification compared to the literature and finalised.

The demonstration will involve the prototype implementation of the three modules using a React Native front-end and Node.js microservices back-end. Plans for user testing will recruit fifty students from Galgotias University, stratified by novice, intermediate and advanced training experience and from a range of Indian regions.

Assessment will include the cultural acceptability of the meal planning engine using the Cultural Food Acceptability Scale, the scientific authenticity of the training program using a new Exercise Science Fidelity Index developed for this study, and the blog's quality, using the accuracy, readability and personalization relevance experts' rating scales.

5. System Architecture and Technology

The system design for GUTS BARBELL is scalable, multi-platform and easy to integrate with AI algorithms. All parts of the stack have been chosen for this purpose rather than ease of development.

The mobile application is built with React Native (version 0.73), enabling the same code to be used for iOS and Android devices. The app's state is managed by Redux Toolkit and asynchronous data is fetched from the backend by the React Query library. The user interface adheres to Material Design 3 principles but using a design system for fitness.

There are three separate Node.js (Express.js) microservices running in the backend. These can be deployed and scaled separately. They interact with each other synchronously through REST for user requests and asynchronously through RabbitMQ message queues for more intensive processing tasks - such as weekly program planning and batch blog generation.

The Meal Planning Service interacts with a PostgreSQL database storing the culturally indexed food database. Meal optimisation uses a constraint satisfaction solver (Python Google OR-Tools), called as a subprocess from the Node.js service. The Program Generator Service contains the entire training prescription logic in Node.js directly using domain logic that encodes the MEV/MAV/MRV (most essential volume/most adjust volume/most recoverable volume) training prescription and progressive overload formulae. The Blog Generator Service invokes the OpenAI GPT-4o API asynchronously, injecting system and user queries to generate blog posts.

JWT (with token rotation) is used for authentication. User health data is encrypted at rest (AES-256) and in transit (TLS 1.3). The software contains health data consent processes and adheres to relevant privacy laws.

6. Results and Expected Outcomes

Given our theoretical underpinnings, system design choices, and the results of similar research reported in the literature, we expect the following outcomes from the GUTS BARBELL system following the deployment and testing of the prototypes.

With respect to the meal planning engine, culturally targeted plans are likely to have at least a 4.2 mean Cultural Food Acceptability Score (out of a possible 5.0) across regions. Energy/macronutrient accuracy is expected to be within five percent of calculated daily energy/macronutrient needs for at least 90% of plans. Adherence to meal plans (calculated as the proportion of users meeting meal logging targets) - used as a measure of acceptability - is expected to

outperform the controls (generic meal plans) by 20-30%; in line with cultural adaptation findings in other dietary intervention programs.

For the hypertrophy program generator, programs will be rated 4.0 or above out of 5.0 for scientific validity by a panel of registered strength and conditioning coaches comparing the programs with published evidence-based guidelines. Progressive overload adherence (defined by the percentage of users who improve their performance over an eight-week testing period) is expected to be greater than 70% for novice and intermediate users.

In the blog generator, expert ratings of accuracy are expected to be 3.8 or higher (on a 5-point scale), with users rating the personalization relevance at 4.0 or higher. Daily active users is expected to positively predict commitment to reading blogs, as is seen in other mobile health content delivery apps.

7. Discussion

GUTS BARBELL offers a solution to an issue that is of little concern to the fitness app market: the fact that users of these apps are not all equally created, do not all eat identical foods and do not all have identical levels of fitness. The app's tri-module structure is a purposeful choice of personalization as a structural necessity.

The cultural responsiveness of the meal planning engine responds to a common problem in digital health technology. Nutritionally accurate dietary advice that is in practice incompatible with a user's food culture is dropped. This is not a first world problem for persons in India, many South Asian and Middle Eastern countries, or sub-Saharan Africa; it means that most of the available fitness nutrition tools are irrelevant to them. GUTS BARBELL does this by starting with culturally relevant ingredients and building up to meals rather than starting with a westernised dietary regime and working down to ingredients.

The program generator, which uses MEV/MAV/MRV, brings a level of exercise science to people who would otherwise have only access to it via costly personal training. The health ramifications of this are considerable: training with the right kind and volume of resistance exercise has been shown to decrease all-cause death rate, to improve metabolic profiles, and to improve mental health. A more accessible means of generating well-calibrated training programs isn't simply a convenience, it's relevant to public health.

The blog generation system addresses the stagnation issue of most current fitness apps. Information that doesn't stay current with interests and ability is soon out of date. Generating new content every day that is tailored to the user's needs and interests forms a different relationship: it is one of continual learning rather than a "once-off" exercise program.

It is worth cautions readers about the ethics of AI-generated health content. Language models can hallucinate, and in health care, there is risk in hallucinations. The strategy of domain-specific prompting, and the content moderation, built in to GUTS BARBELL helps, but it doesn't solve this problem completely. The app therefore features clear disclaimer screens which make it clear that the application is not intended to provide medical or clinical advice, and that users with diagnosed medical conditions should seek advice from a clinician.

8. Conclusion and Future Work

This paper has outlined the design, theoretical underpinnings and anticipated benefits of GUTS BARBELL, a mobile fitness app based on three distinct modules: a culturally sensitive meal planner, an evidence-based muscle-building program generator and culturally sensitive AI-based blogging content generator. The justification for this project is simple - the market is large and growing, and failing many of its customers by attempting to personalize as an aftermarket service.

The distinction of GUTS BARBELL is not in any particular technology decision, but in the integration of three areas of personalization - nutrition, exercise and educational content - into a unified system, and all centred on the person. The meal planning engine's integration of locally relevant food databases with evidence-based macro-nutritional targets is a practical innovation that has implications for adherence. The program generator's use of volume landmarks and dynamic auto-regulation brings the expertise of a coach to a mobile device. The smart blogging system using LLMs offers a way to scale fitness education, at a scale impossible for human content teams.

The future work planned includes: First, a full prototype will be developed and tested with a range of users to confirm the design ideas proposed in this paper. Second, the culturally indexed food database will be extended to include foods from the Southeast Asian, Middle Eastern, African and Latin American cultures for wider use. Third, data from wearable devices, especially heart rate variability and sleep data, will be used in the auto-regulation module, enabling recovery management to react to more objective data than just self-reported measurements. Fourth, longitudinal studies will be conducted to examine the effectiveness of hypertrophy, dietary adherence and fitness literacy improvement over 12 and 24 weeks. Finally, we will investigate the blog generation system as a federated learning system where personalization models are improved by collective patterns in user engagement but individual data is not shared.

GUTS BARBELL is really not a fitness app, but an attempt to incorporate evidence-based fitness knowledge into a market that has excluded historically marginalised groups. This is the work this paper starts.

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