COM 1001

Introduction to Software Engineering

Professor Phil McMinn

Introduction to Relational Databases and SQL

Transience vs Persistence

When a program terminates, the memory containing program data (i.e., values in variables) is **erased**. We say that this data is **transient**.

Most useful programs – including web applications – will need certain data to **persist**.

Commerce application:
Customer information, current orders, stock levels, etc.

Online learning environment:
Student logins and information, details of learning materials, assessments and marks.

One way to achieve persistence, as well as a means to efficiently store and retrieve information, is to store data in a database.

Databases

A database consists of **data** and **rules** pertaining to its organisation.

Access and modification of the data is handled by a **Database Management System (DBMS)**.

A DBMS can run as a server, accepting multiple connections at once involving requests for data and/or updates to that data.

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Relational

NoSQL

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MongoDB, Cassandra, HBase, Neo4J … and literally tens to hundreds of others

SQLite

Simple and self-contained, **little to no configuration** required

Often the choice for web developers for developing web applications

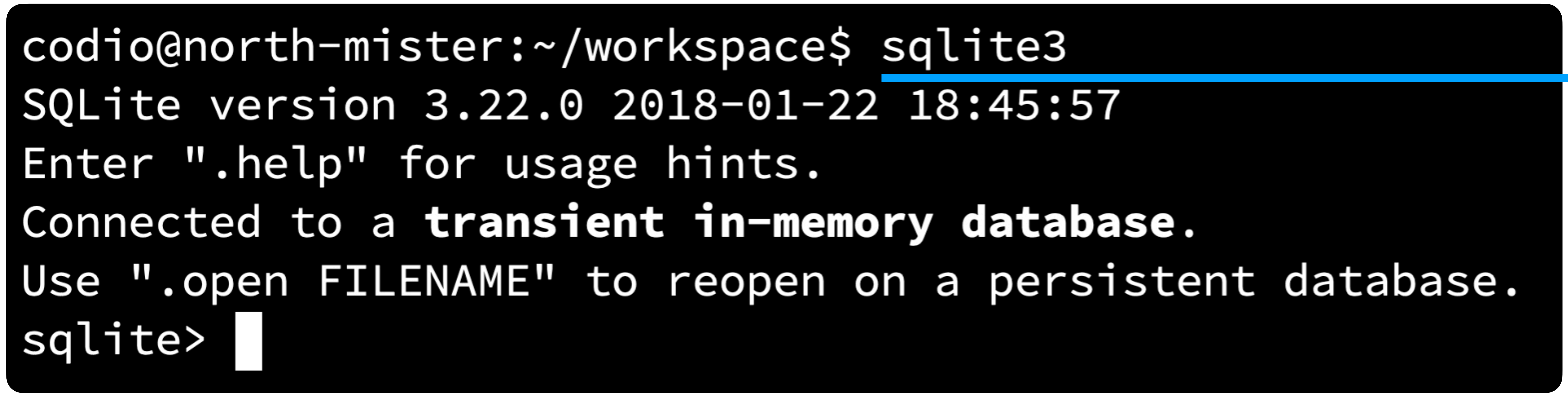
For deployment, developers tend to prefer an enterprise database that is better optimised for heavy concurrent access, such as PostgreSQL

Forms the basis of many desktop and mobile applications

e.g. Chrome and Safari, and numerous other well-known applications

Pre-installed on Mac OS and Linux.
For other types of OS see **https://www.sqlite.org**

Using SQLite



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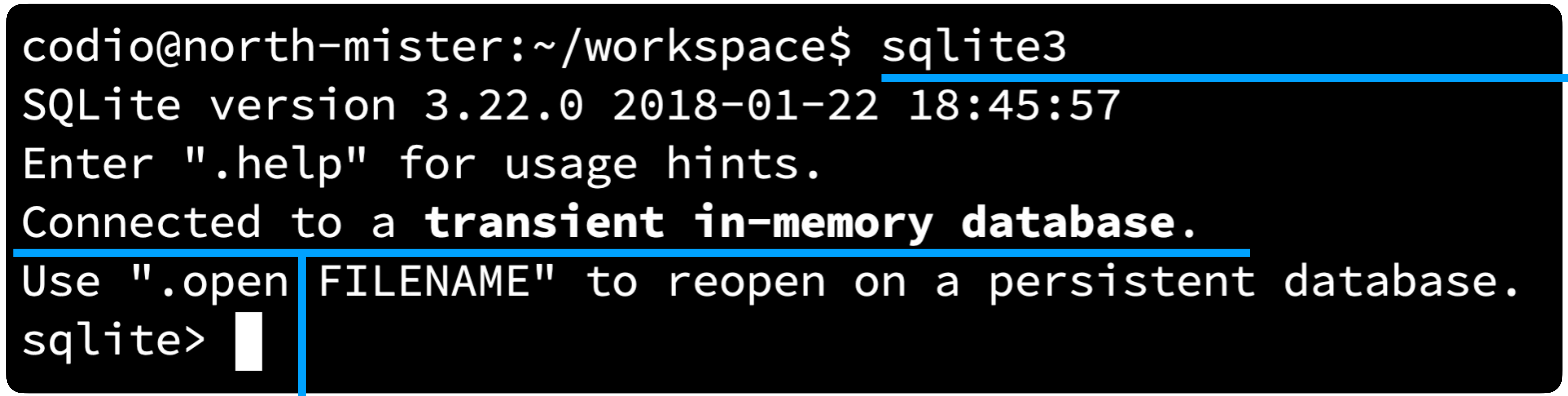

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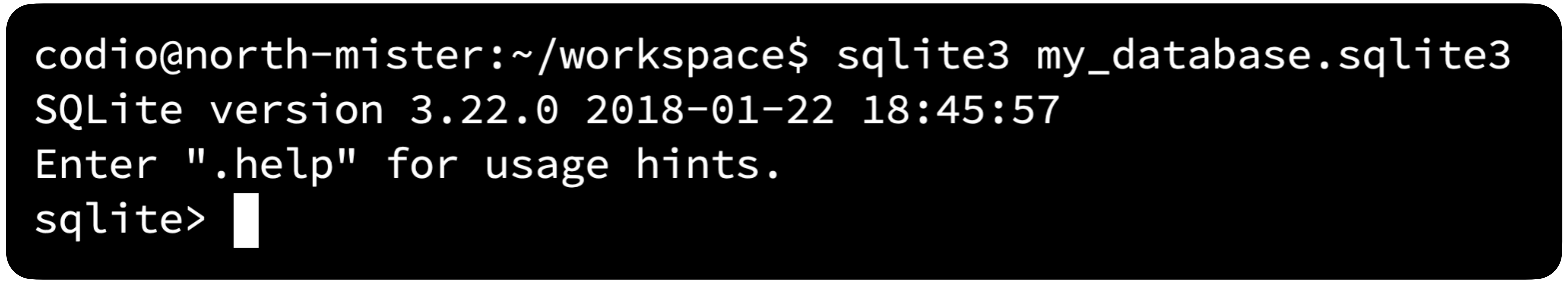

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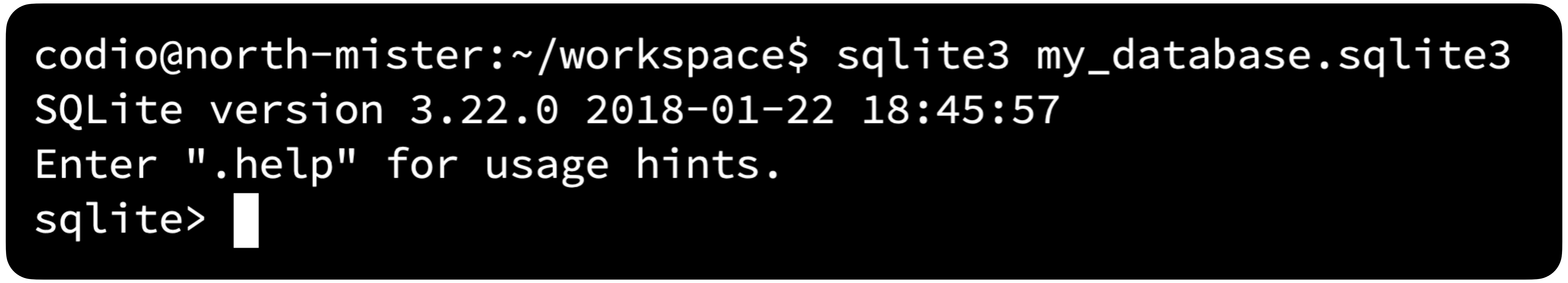

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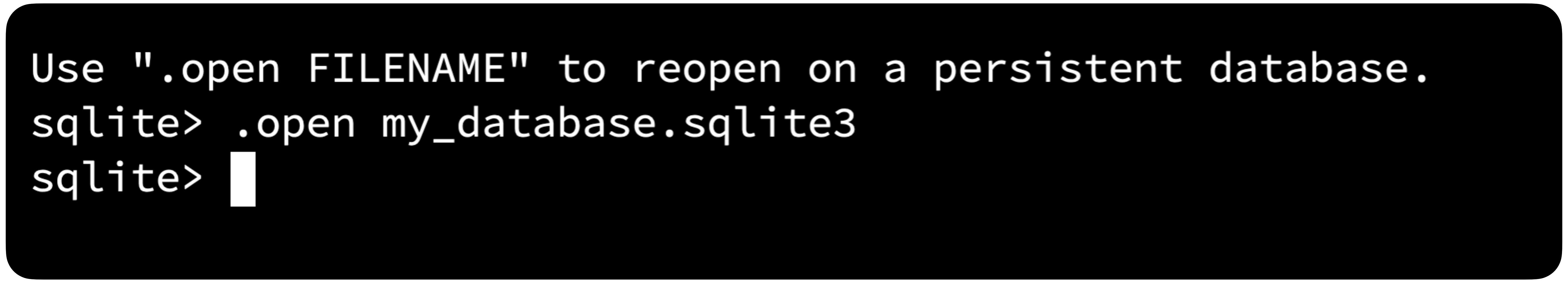

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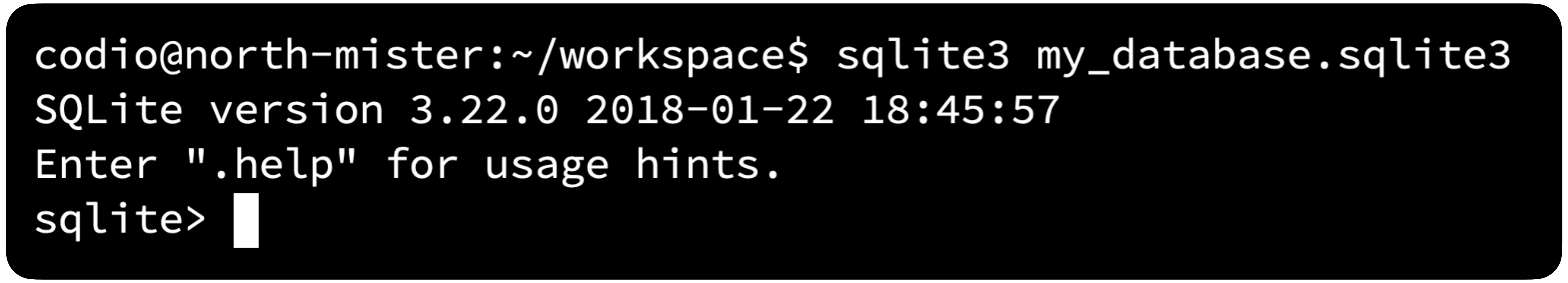

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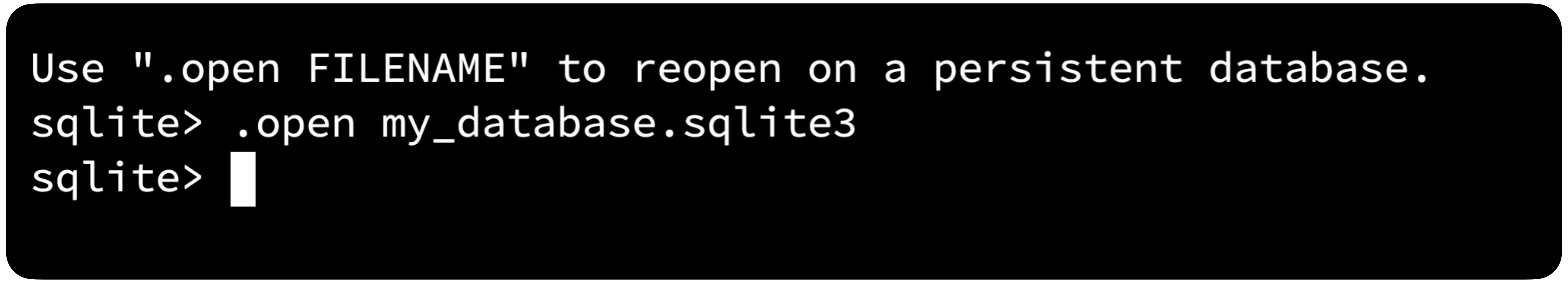

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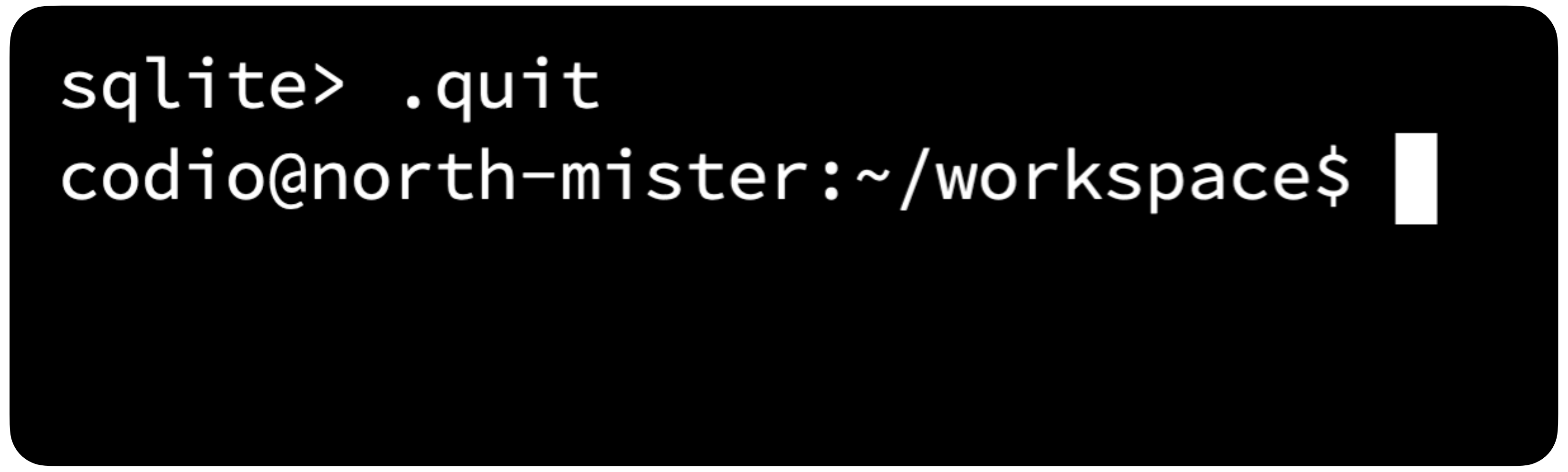
To exit, and get back to the shell, we use the `.quit` command:



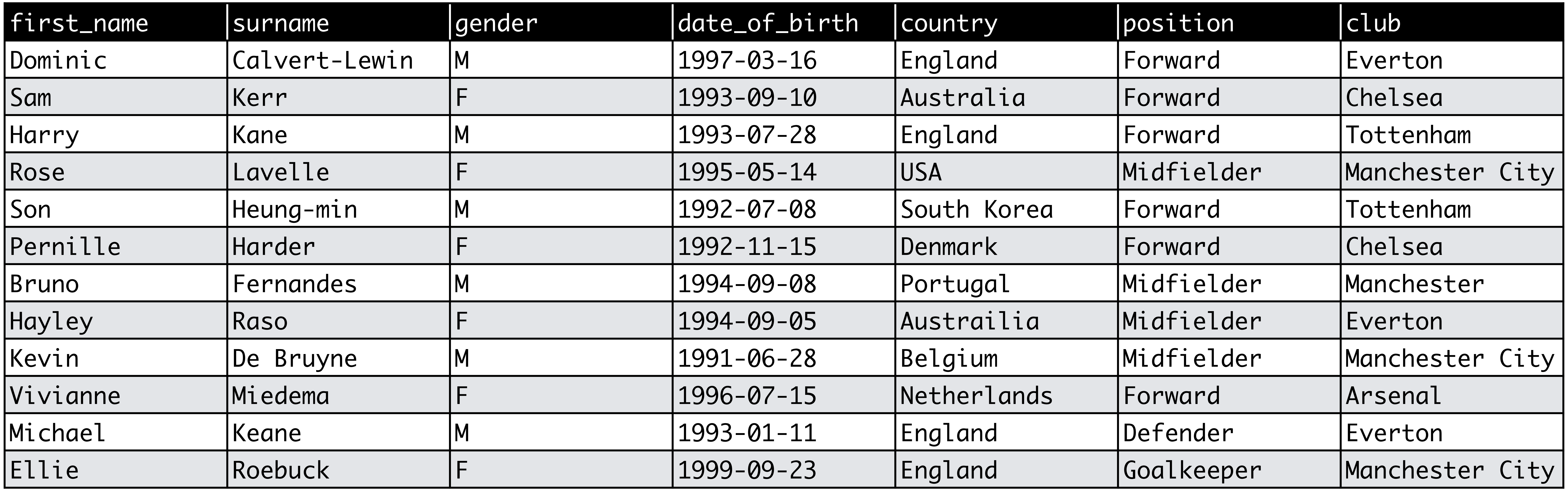
```
sqlite> .quit
codio@north-mister:~/workspace$
```

SQLite is a Relational Database

Data in a relational database is organised into **tables**

Each **row** represents a **record** of information

Each **column** denotes a named **field** of the **record**



first_name	surname	gender	date_of_birth	country	position	club
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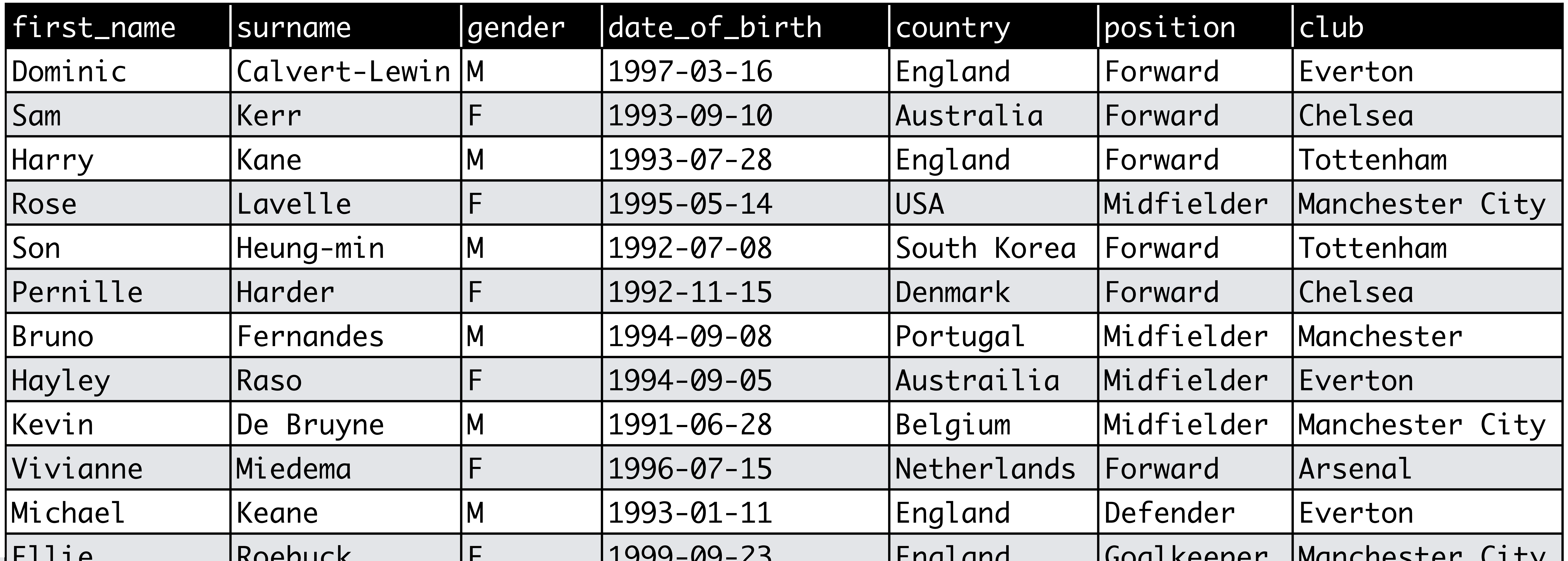
Each Table Requires a “Key”

Each table requires one or more columns whose rows will contain unique values, and so can uniquely identify a row. These column(s) are called the **primary key** of the table.

A primary key could be a name in table of people, for example, but often a name is not unique enough – two people may share the same name.

We could combine names with other pieces of information, e.g. a date of birth, but this may also not be unique.



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Try to think of some real world examples of this… (e.g., your UCard number)

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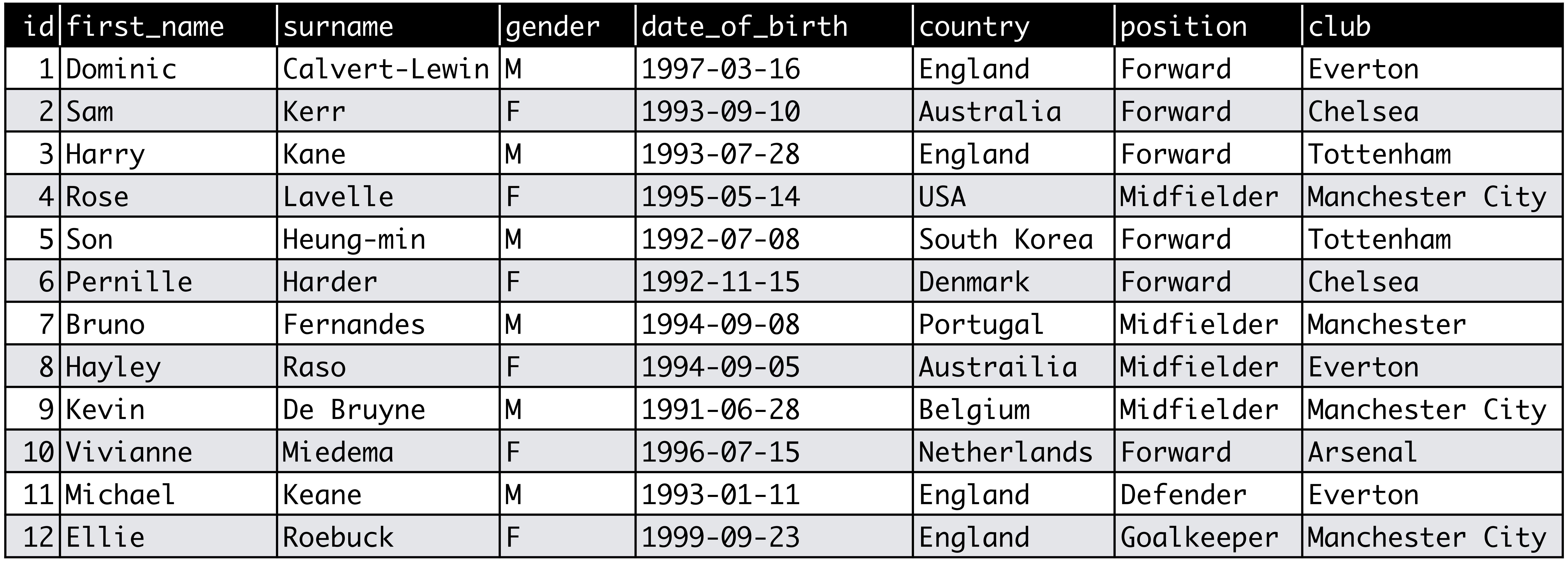

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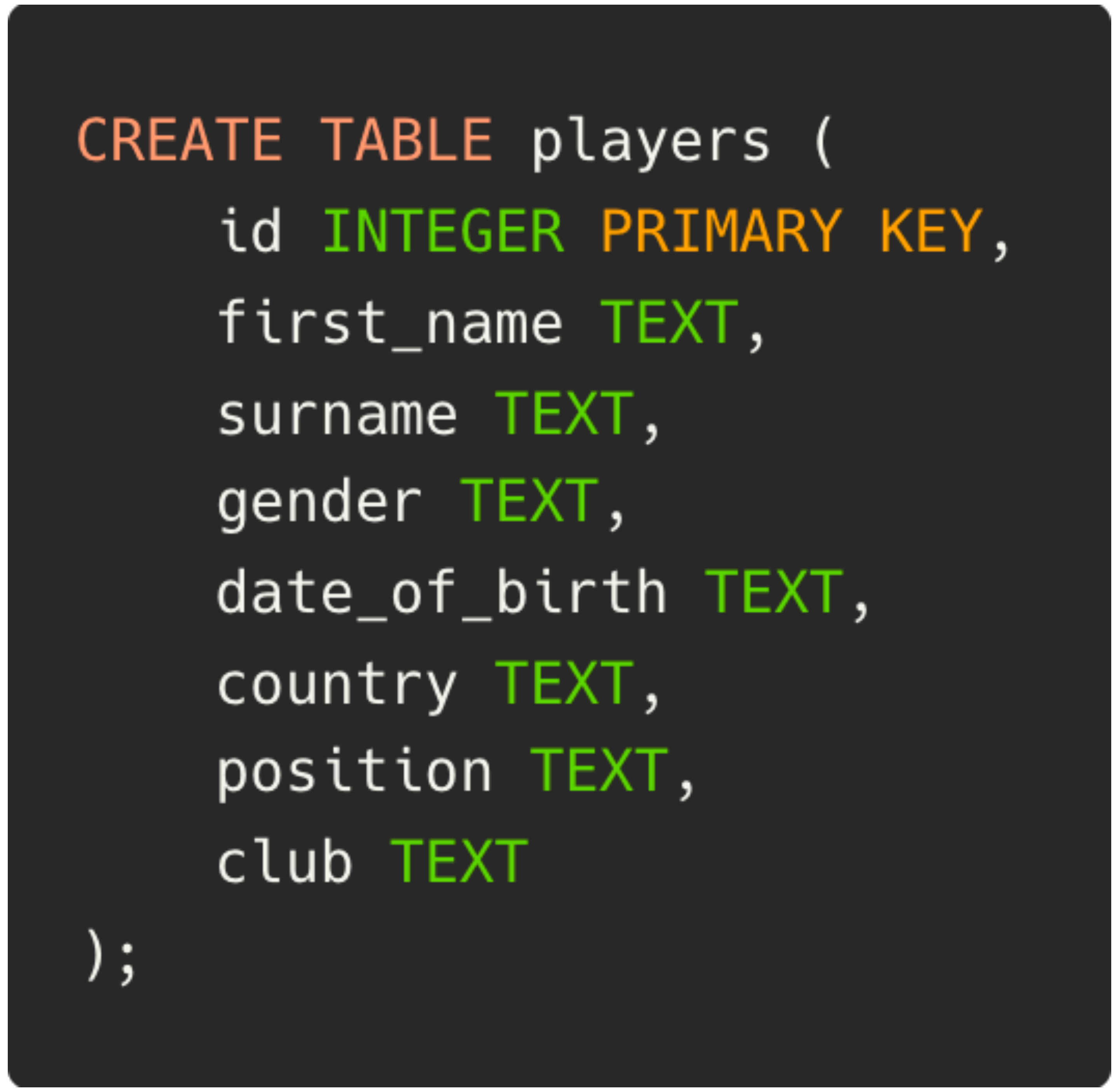

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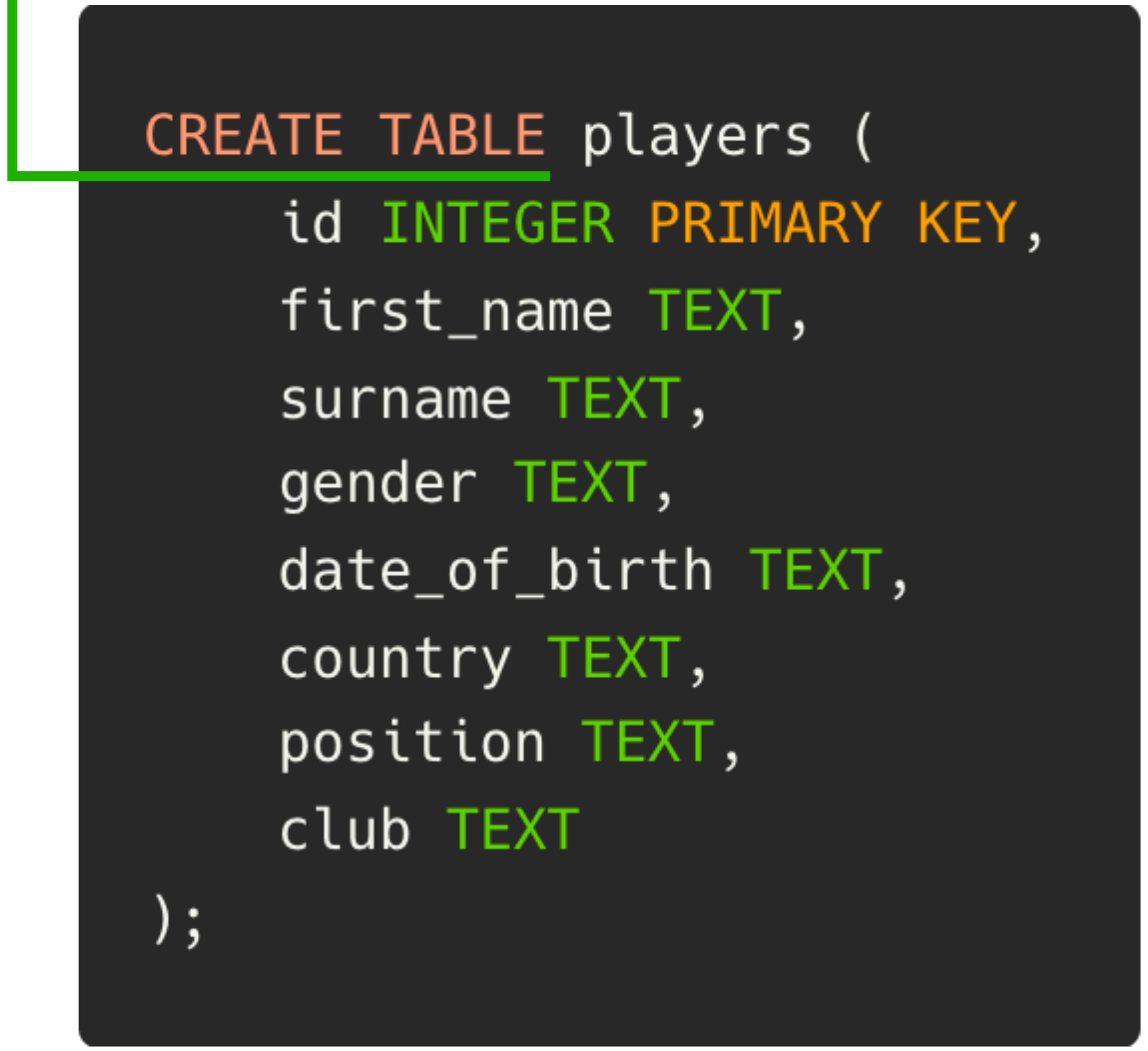

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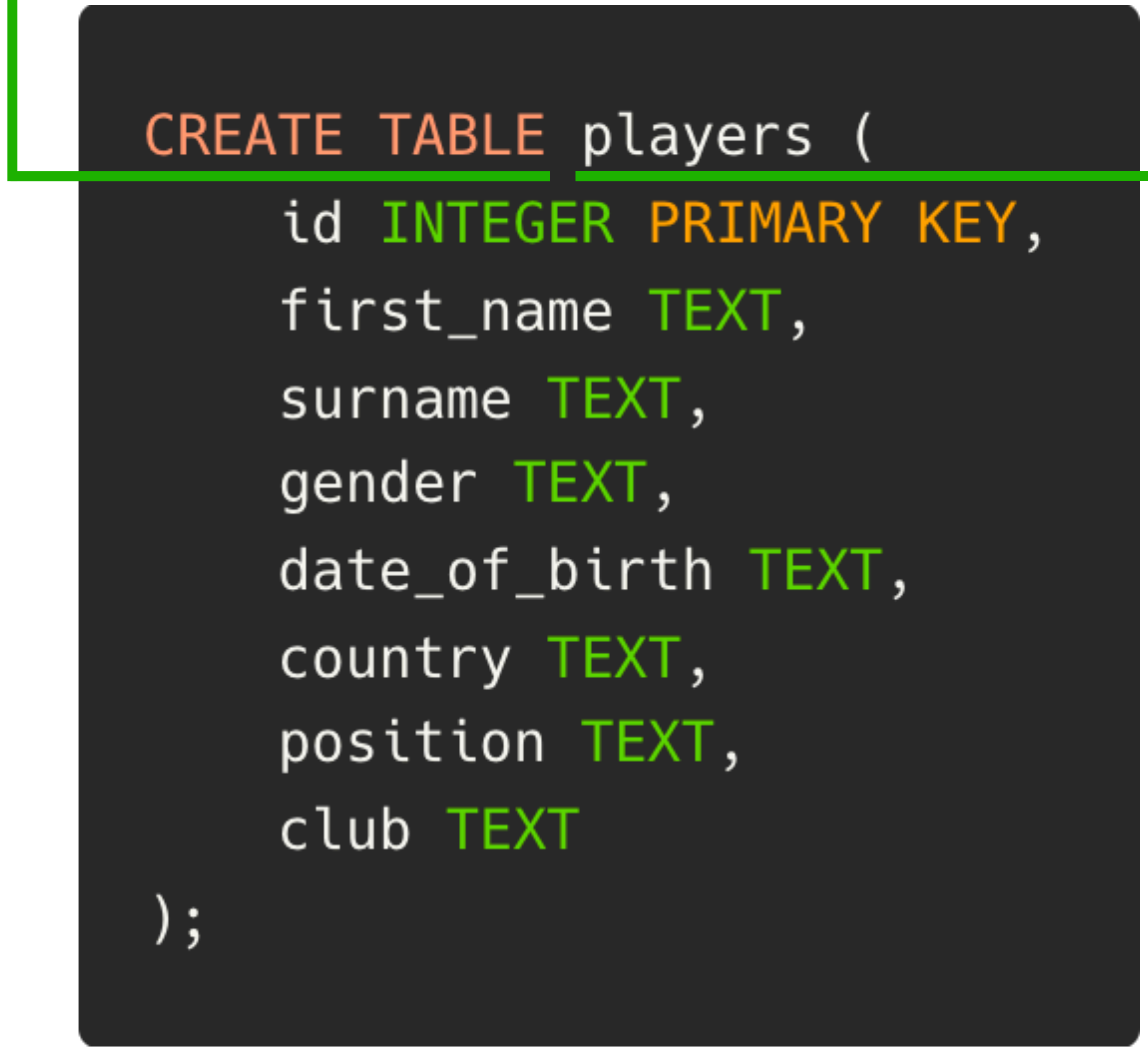

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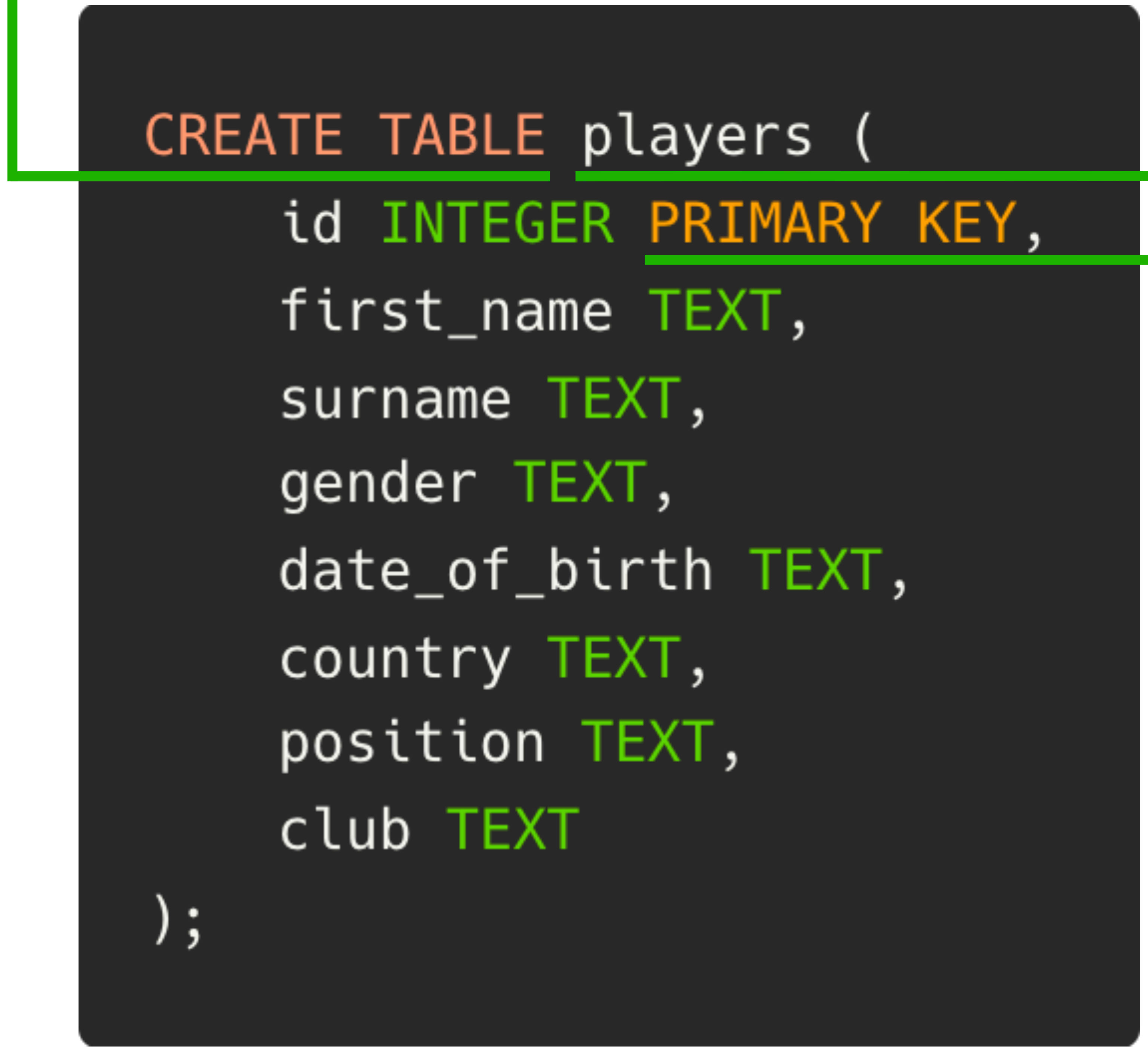

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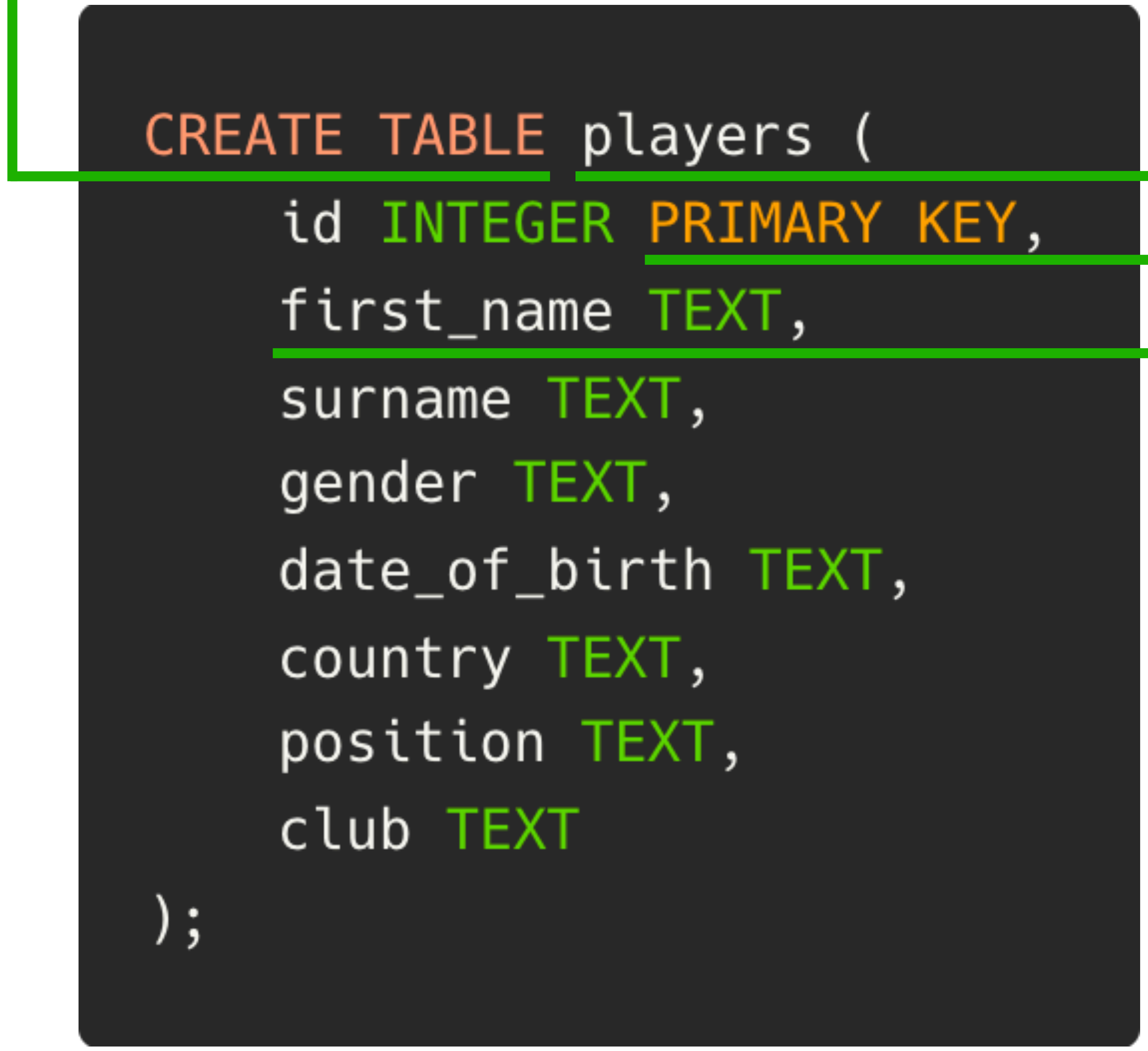

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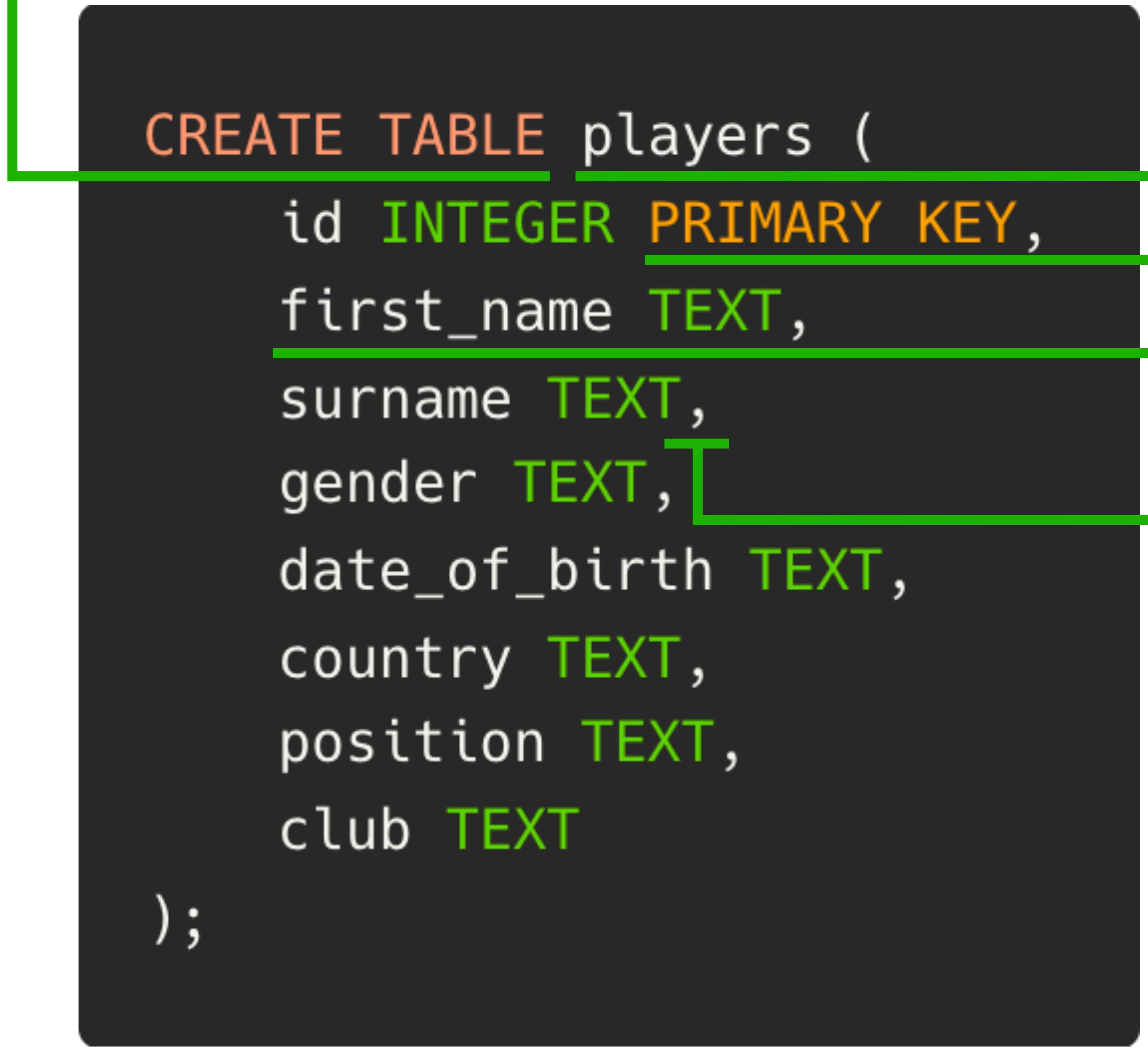

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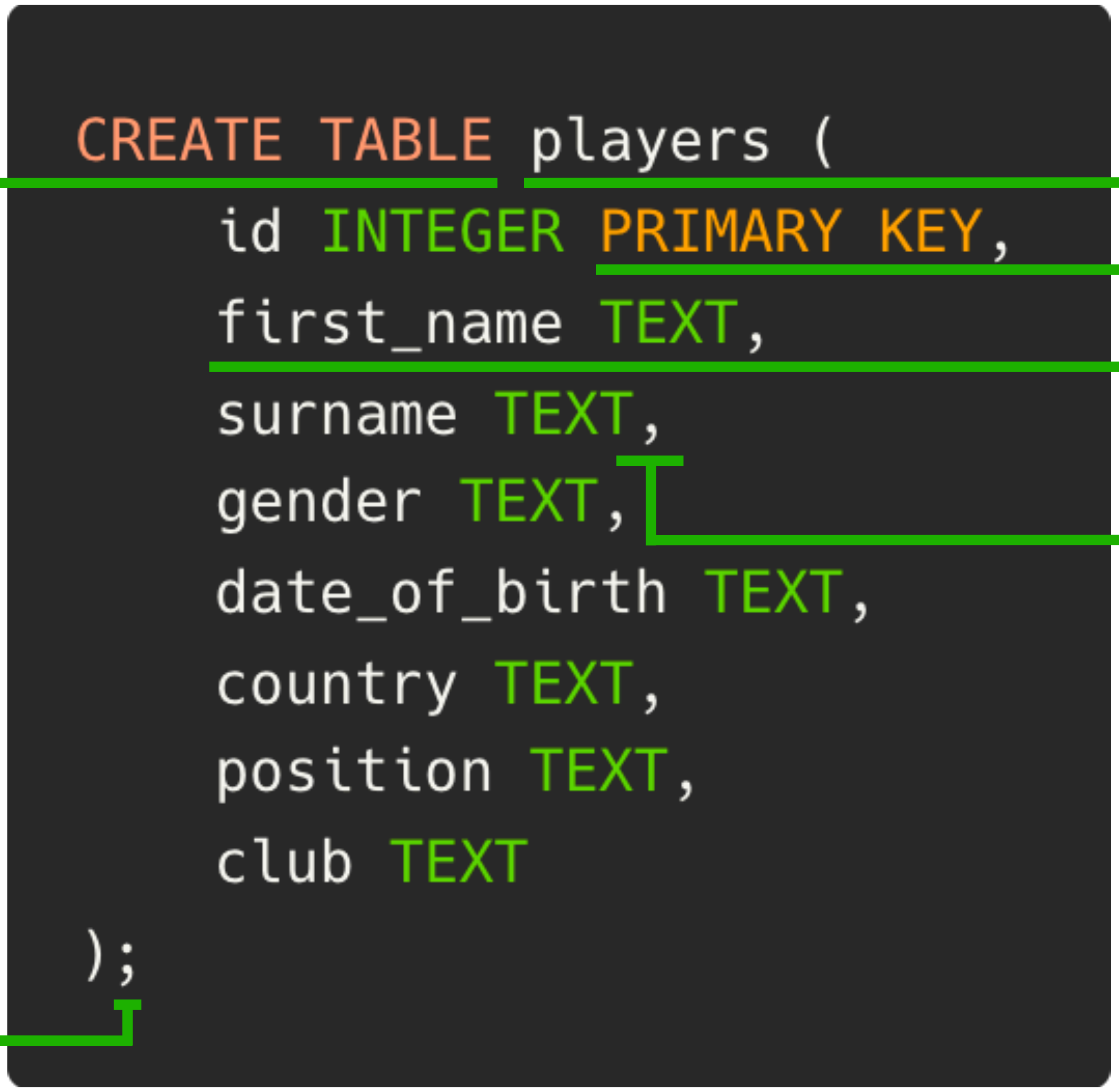

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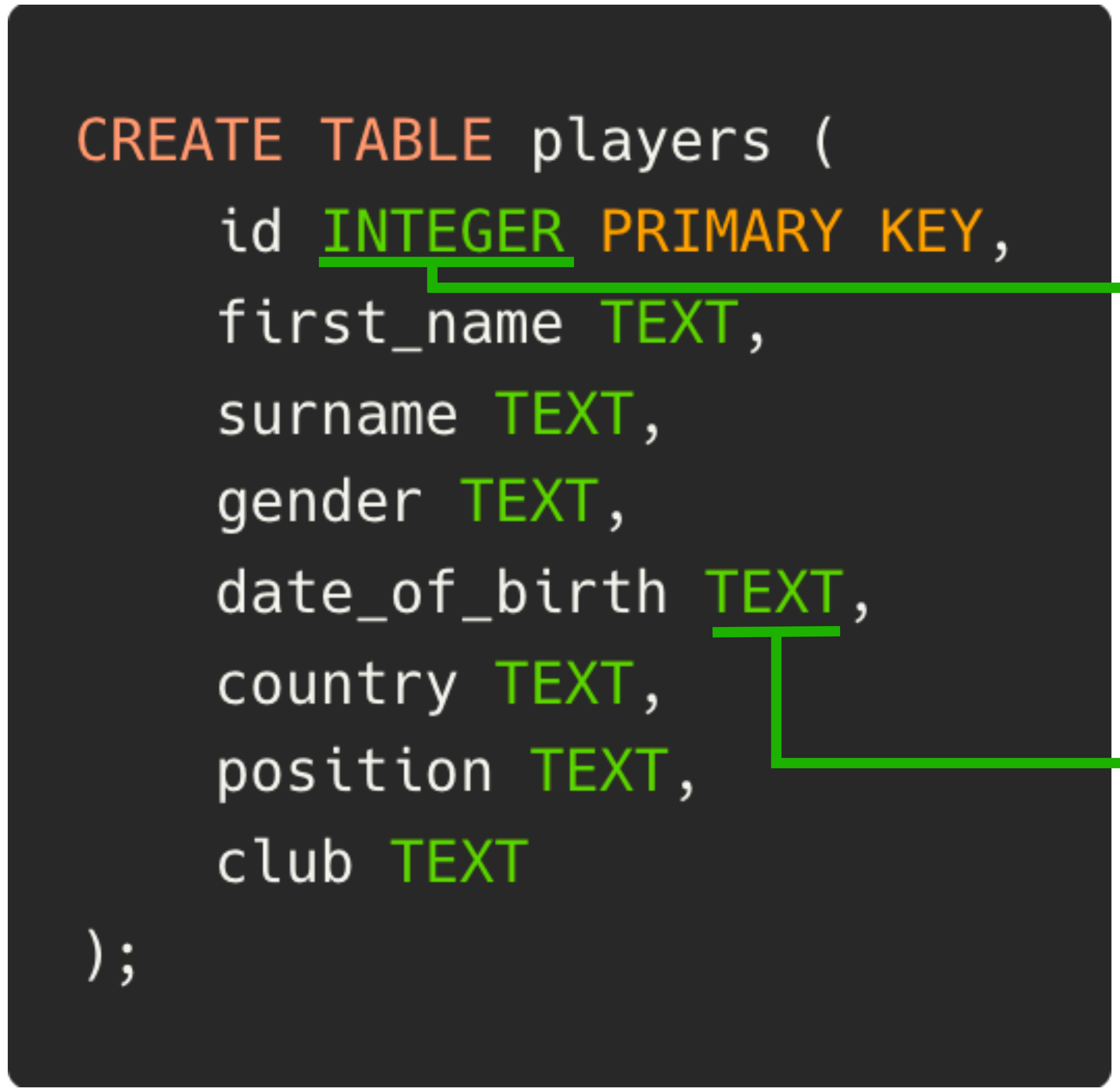
SQL statements are terminated with a semicolon

Data Types in SQLite



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SQLite has **five** main data types:

INTEGER

NUMERIC — The difference between NUMERIC and INTEGER and REAL is subtle, and partly exists to maintain compatibility with other DBMSs. It's ignorable from the point of view of this module.

REAL — Floating point numbers

TEXT — Strings

BLOB — BLOB stands for Binary Large OBject. BLOB database fields store binary data like images and other types of document in a database. We won't be using them in this module.

What’s missing?

INTEGER

NUMERIC

REAL

TEXT

BLOB

There is no BOOLEAN type.

We need to use an INTEGER instead, where 0 = FALSE and 1 = TRUE

SQLite does not have special types to manage date and time.

(This is in contrast to many other DBMSs.) Instead we must use the TEXT field. SQLite does have a number of built-in functions that can manipulate these date/time TEXT fields, but we have the option of using Ruby for that anyway.

Compatibility With Other DBMSs

```
INTEGER
NUMERIC
REAL
TEXT
BLOB
```

Other DBMSs offer many more data types, but usually they're just synonyms of one of SQLite's five main types, or restricted versions of them.

For example:

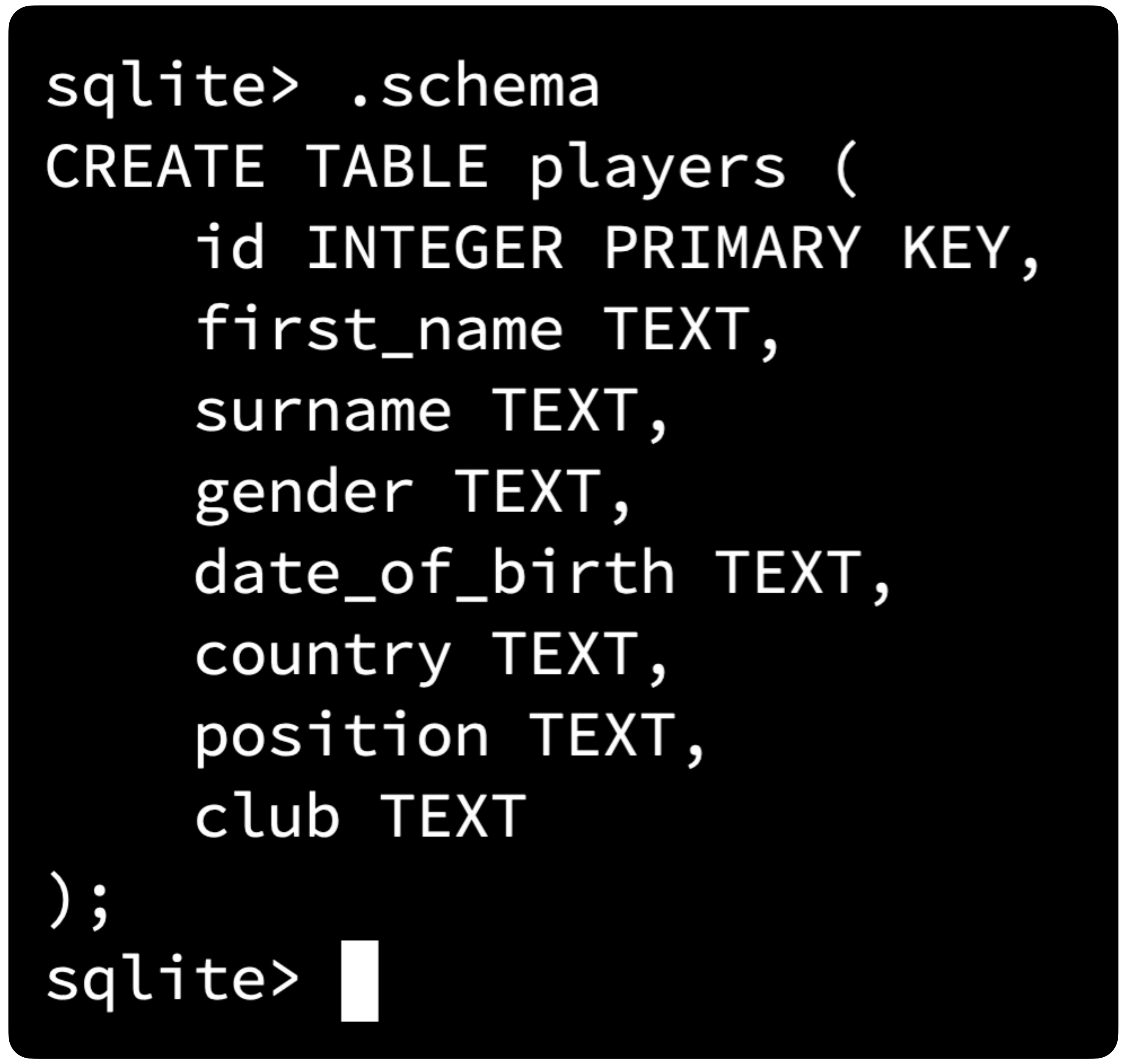
SQLite	Other DBMSs
INTEGER	INT
INTEGER	SMALLINT
INTEGER	MEDIUMINT
INTEGER	BIGINT
TEXT	VARCHAR
TEXT	NCHAR
TEXT	NVARCHAR

SQLite will often let you use these names, to preserve compatibility with these DBMSs, converting them internally to one of its own types.

The Database Schema

The tables, columns, types and other specifics like their primary keys are collectively referred to as the database's **schema**. More on database schemas later in the module.

SQLite will give us back the schema for our database, in SQL, if we use the `.schema` command:



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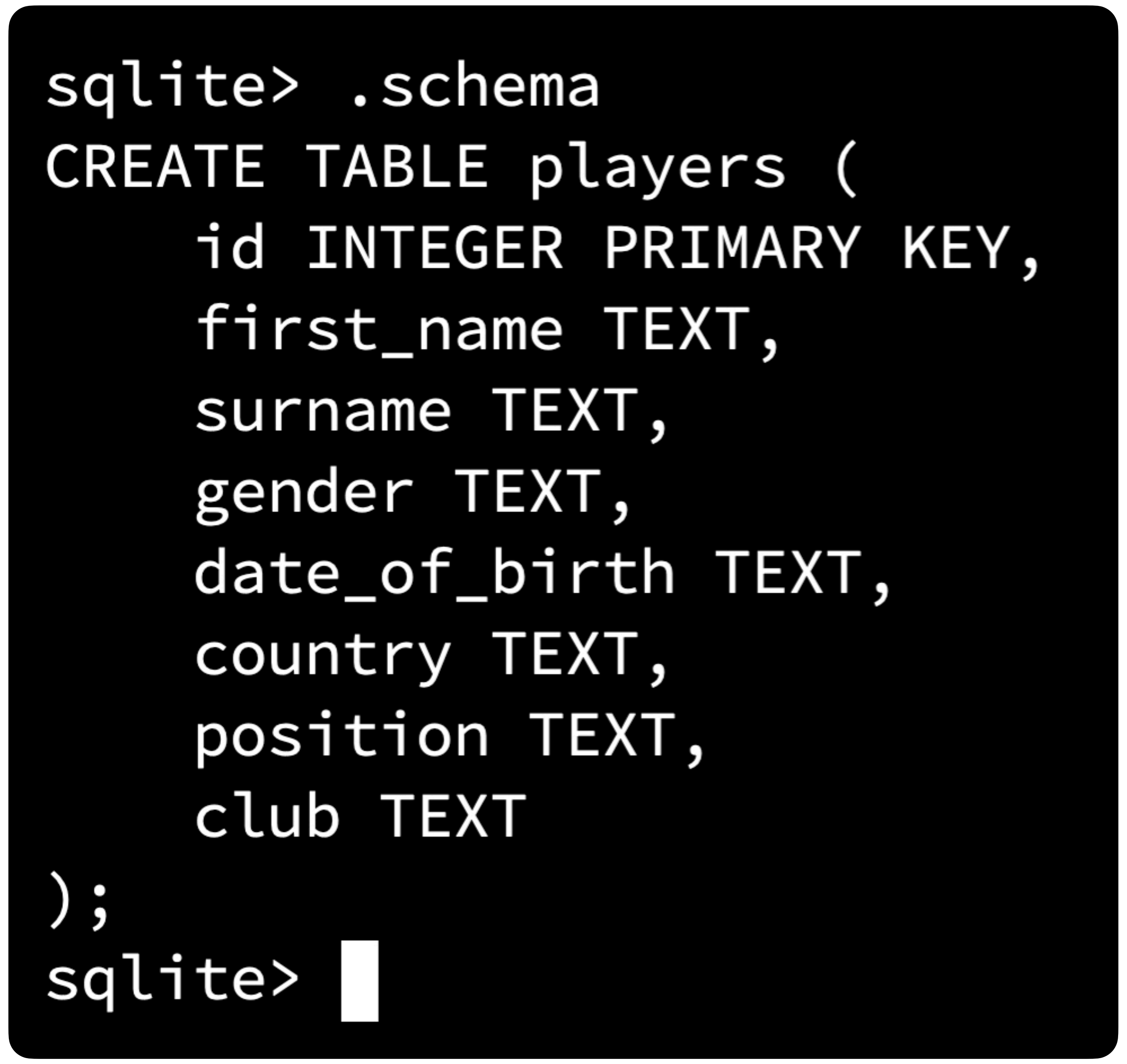
The Database Schema

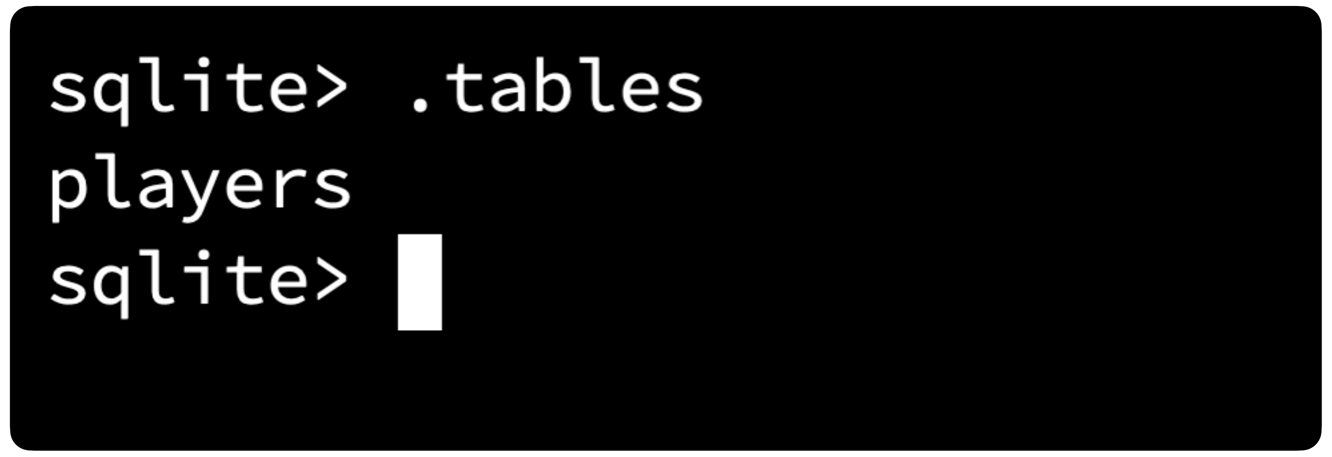
The tables, columns, types and other specifics like their primary keys are collectively referred to as the database's **schema**. More on database schemas later in the module.

SQLite will give us back the schema for our database, in SQL, if we use the `.schema` command:



```
sqlite> .schema
CREATE TABLE players (
    id INTEGER PRIMARY KEY,
    first_name TEXT,
    surname TEXT,
    gender TEXT,
    date_of_birth TEXT,
    country TEXT,
    position TEXT,
    club TEXT
);
sqlite>
```

The `.tables` command gives a list of tables:



```
sqlite> .tables
players
sqlite>
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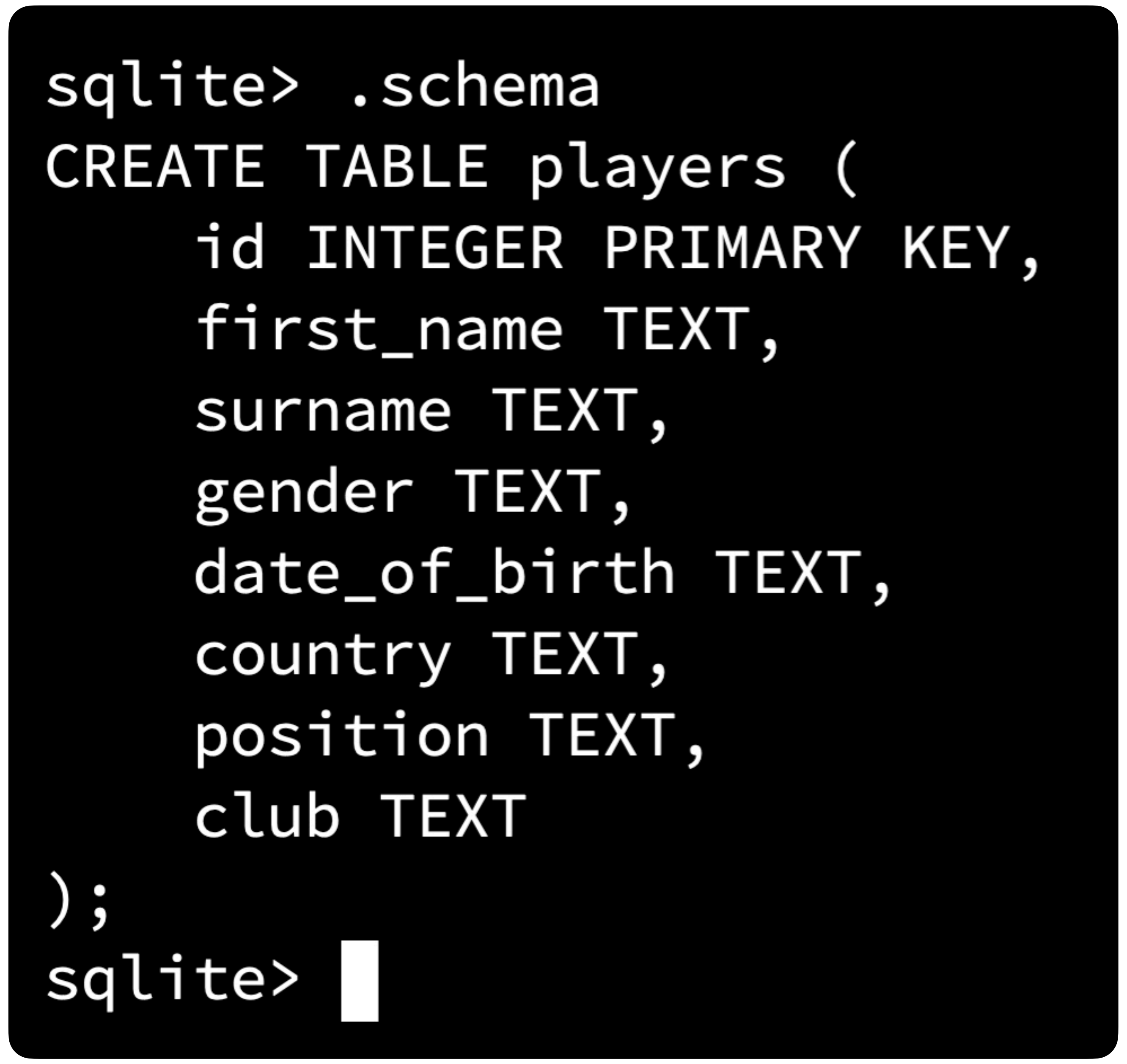

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sqlite> █
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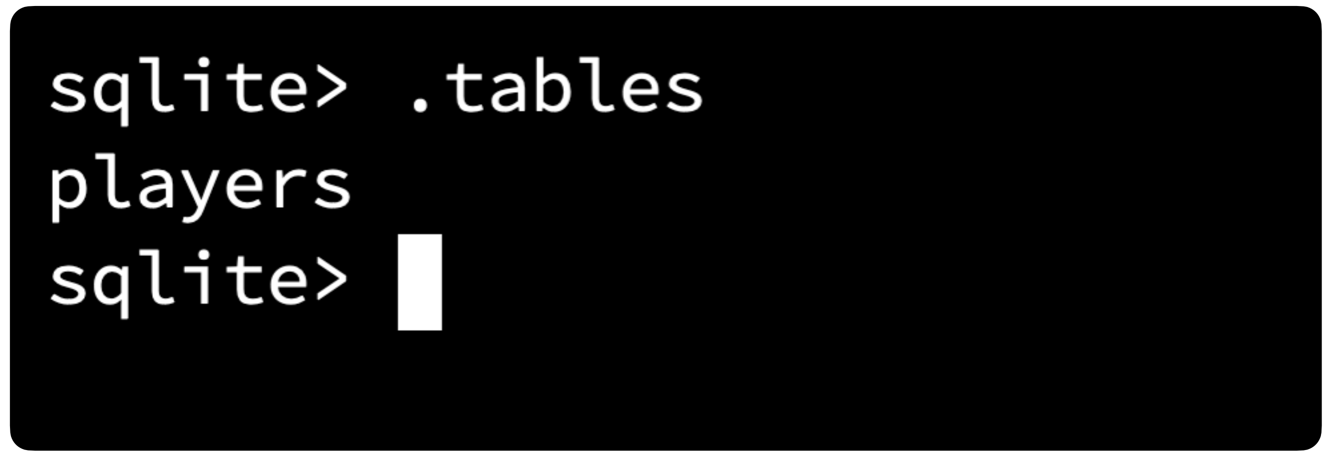
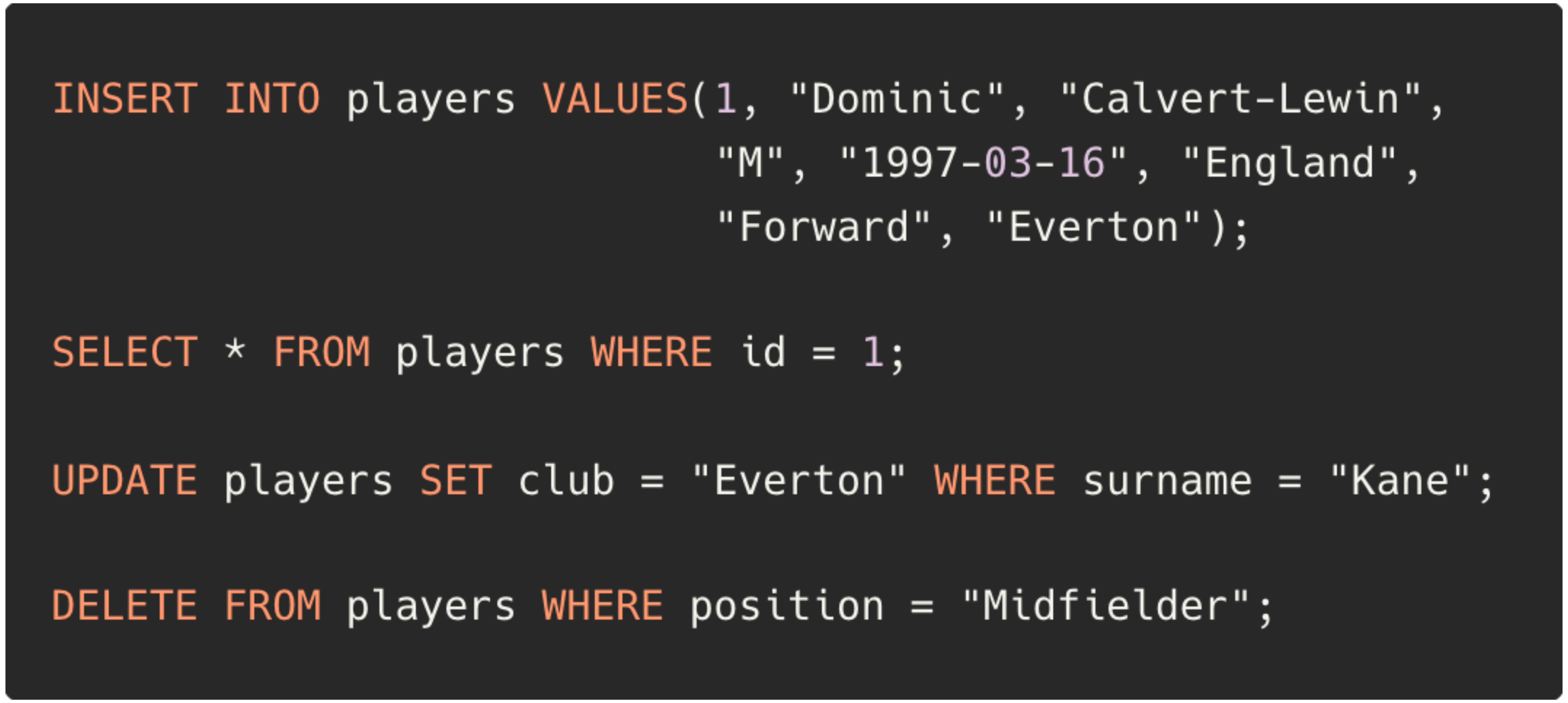


```
sqlite> .tables
players
sqlite> █
```

`.schema`, `.tables`, `.open`, and any command that starts with a period are special SQLite commands.

They are not part of SQL and will not necessarily work with other DBMSs.

Create, Read, Update, Delete (CRUD)



```
INSERT INTO players VALUES(1, "Dominic", "Calvert-Lewin",
                           "M", "1997-03-16", "England",
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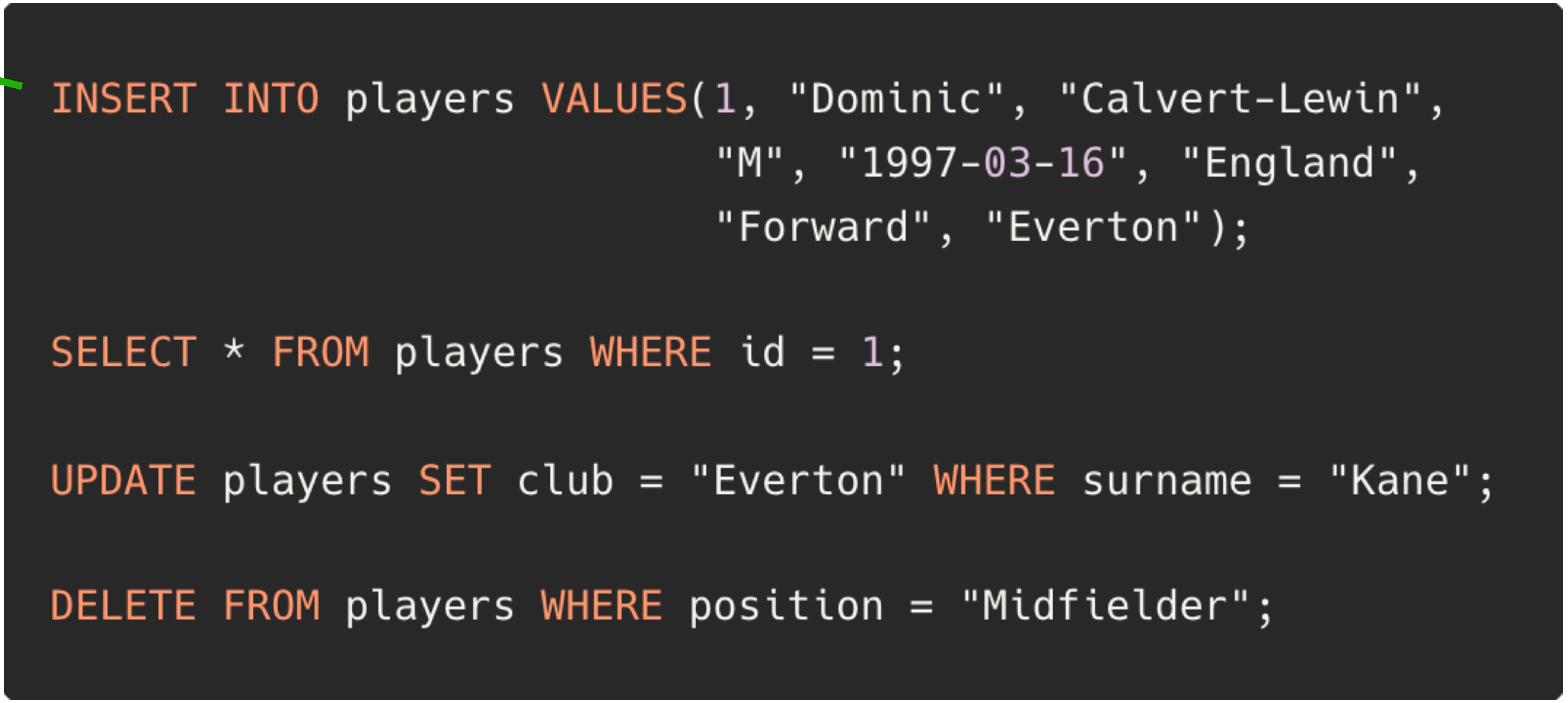
SELECT * FROM players WHERE id = 1;

UPDATE players SET club = "Everton" WHERE surname = "Kane";

DELETE FROM players WHERE position = "Midfielder";
```

Create, Read, Update, Delete (CRUD)

Create. Rows are added to a table using the `INSERT` SQL statement as shown here



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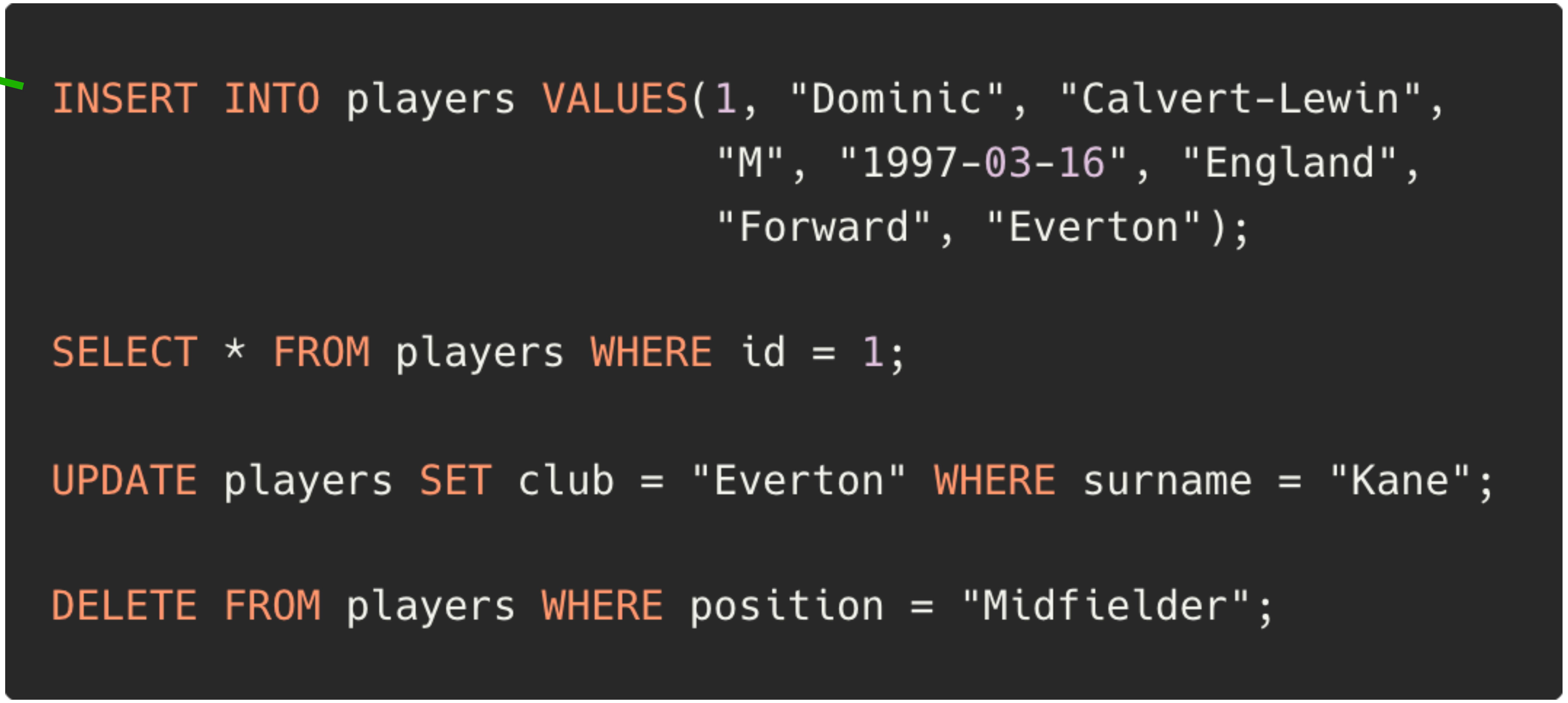
Create, Read, Update, Delete (CRUD)

Create. Rows are added to a table using the INSERT SQL statement as shown here

Read. SELECT queries return the records matching the clause following the WHERE keyword.



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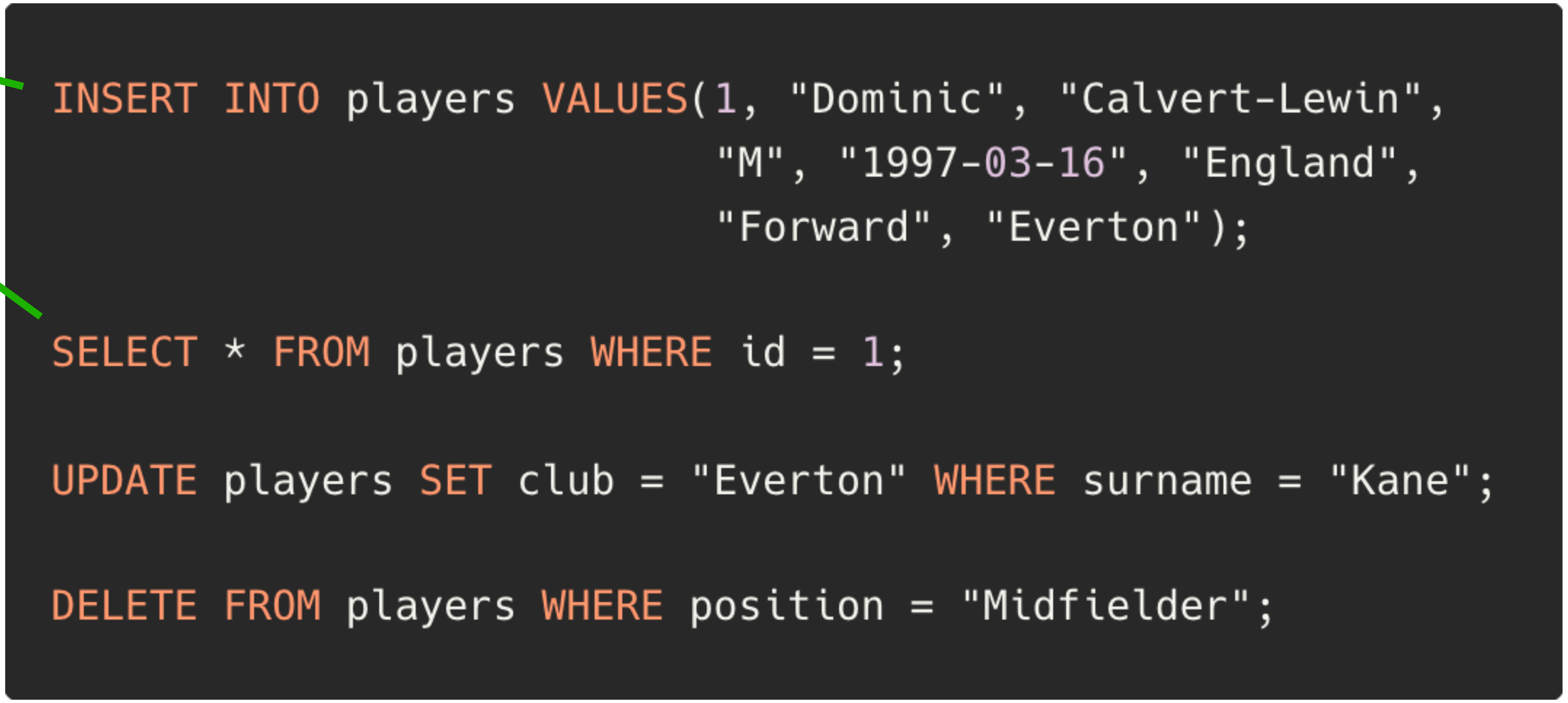

```sql
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Create, Read, Update, Delete (CRUD)

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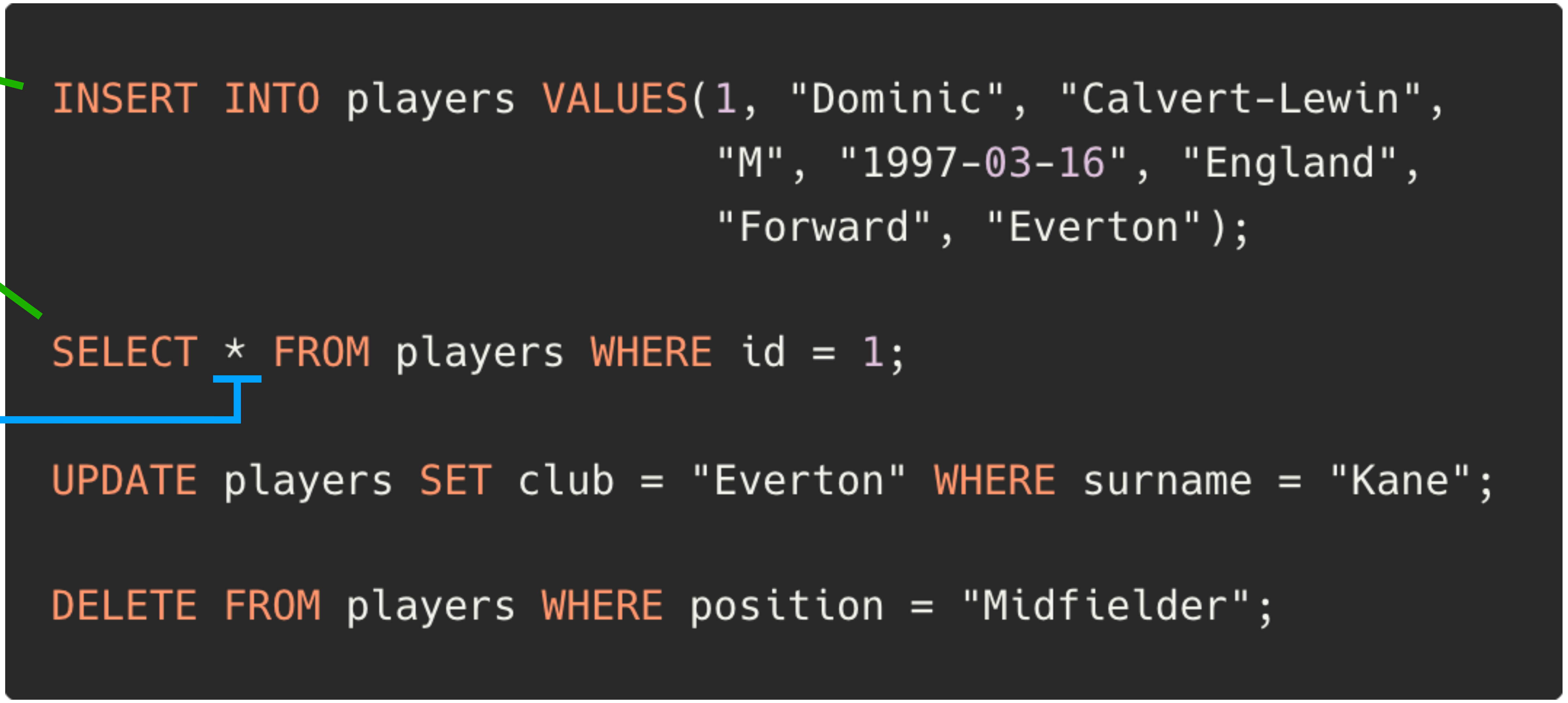
The “*” here means “all columns”. We can specify certain column names instead and get back partial records with only the field values for those columns.



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Create, Read, Update, Delete (CRUD)

Create. Rows are added to a table using the `INSERT` SQL statement as shown here

Read. `SELECT` queries return the records matching the clause following the `WHERE` keyword.

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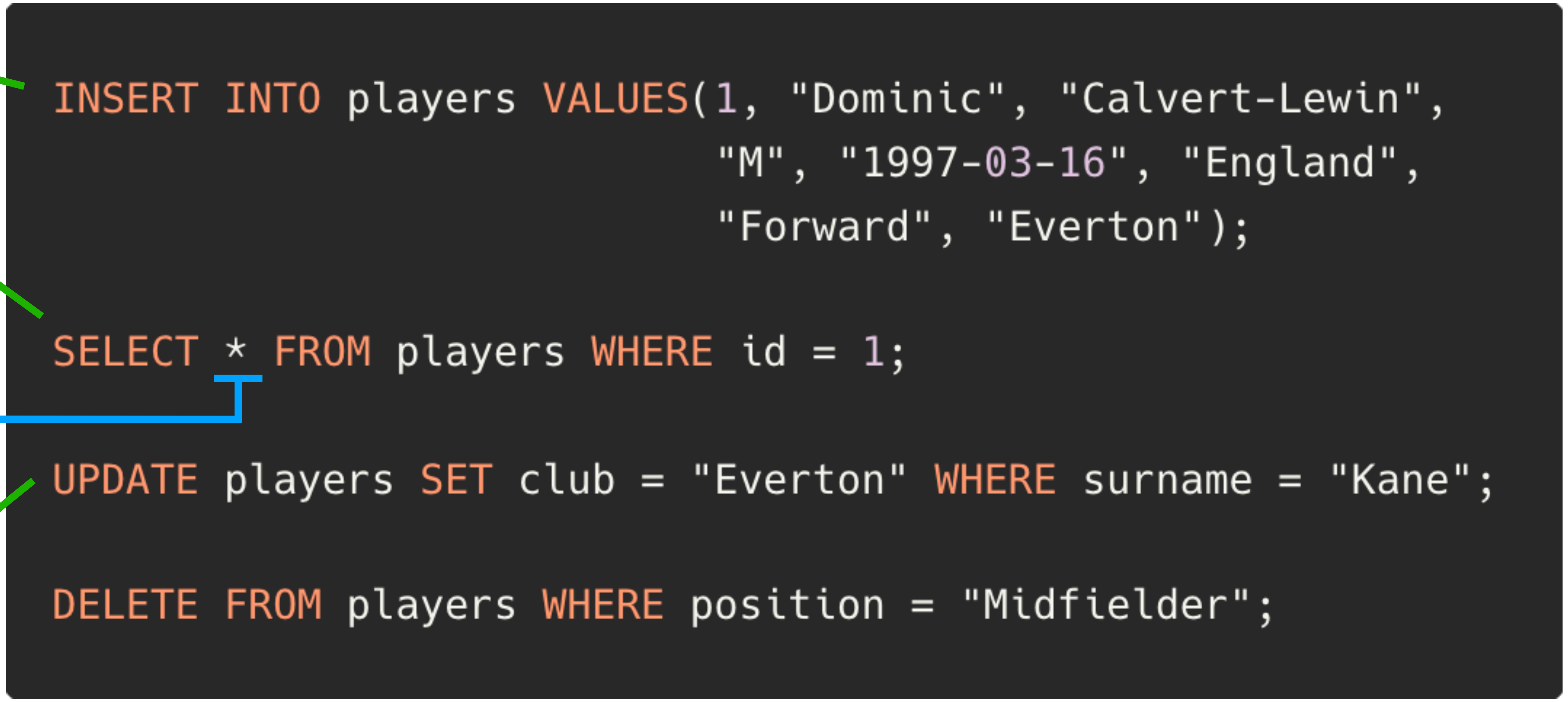
Update. Similarly, we can update certain records using `UPDATE` as shown here, i.e. those that satisfy the `WHERE` clause.



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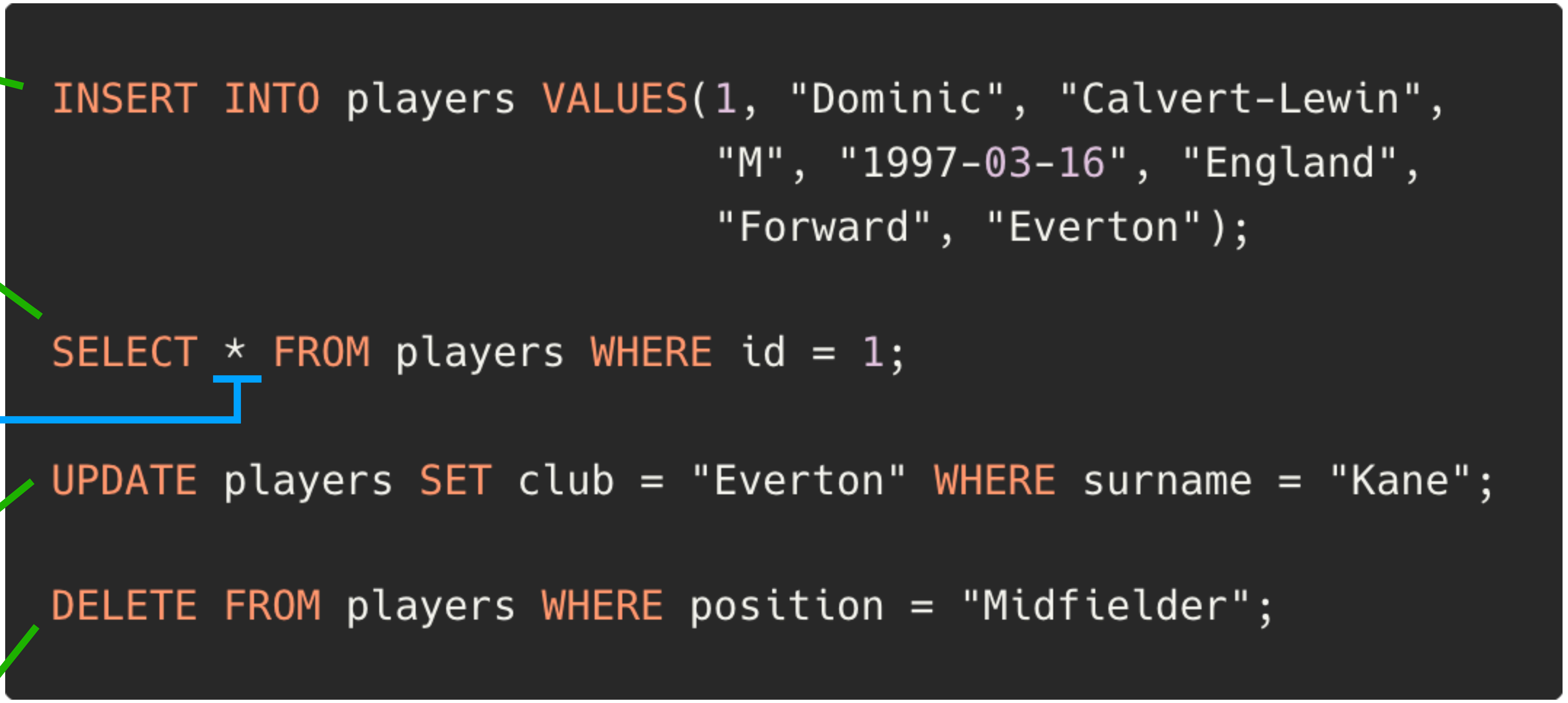
Delete. And finally, we can delete certain records as shown here using the DELETE statement, also qualified using WHERE.



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Create, Read, Update, Delete (CRUD)

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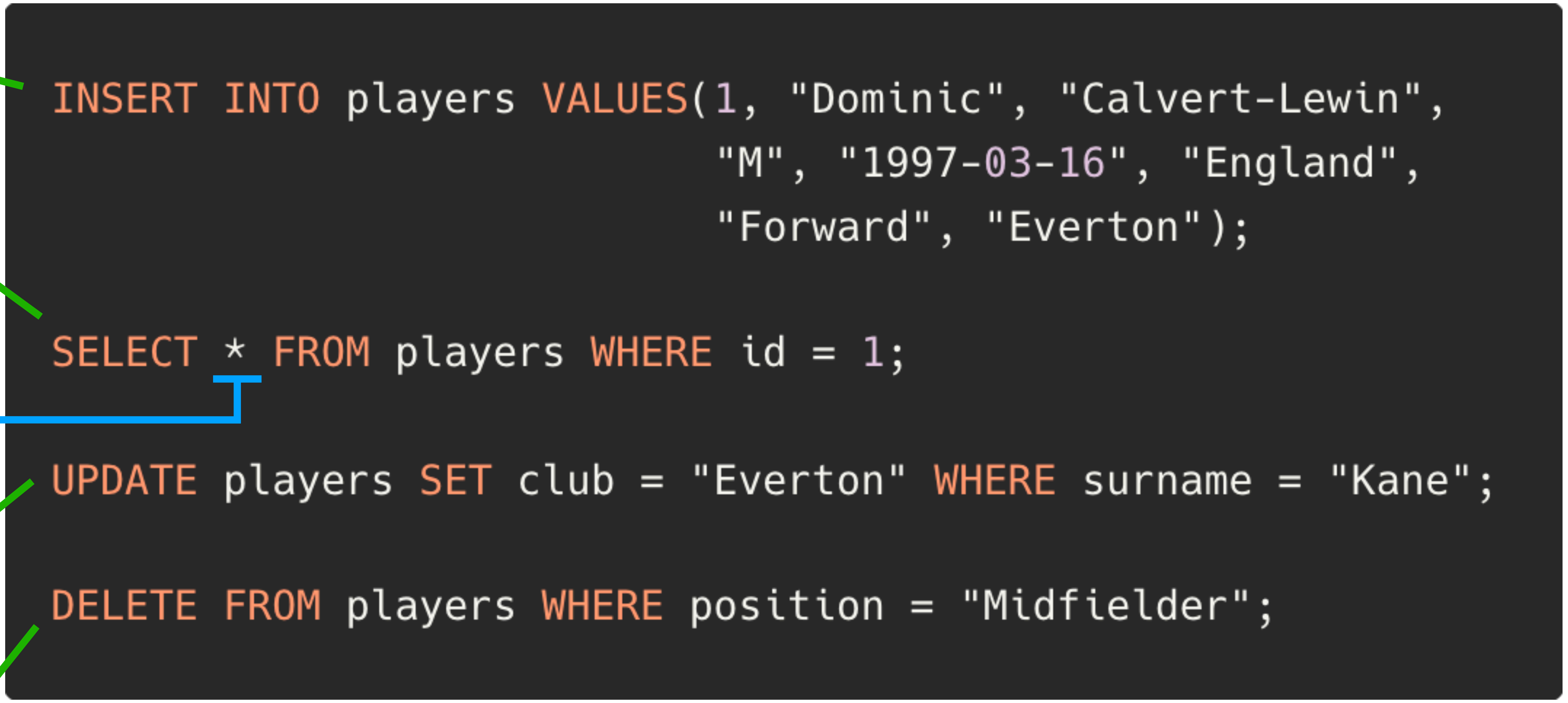

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SELECT * FROM players WHERE id = 1;

UPDATE players SET club = "Everton" WHERE surname = "Kane";

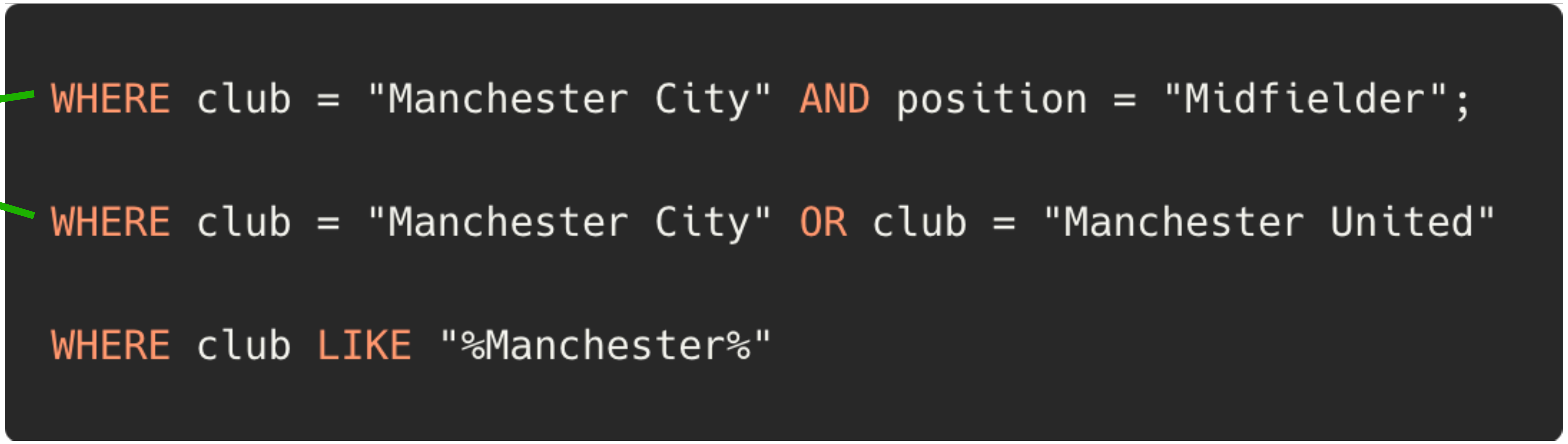
DELETE FROM players WHERE position = "Midfielder";
```

For any CRUD SQL statement, **omitting** the WHERE clause is equivalent to **requesting all the records in the table**.

So guess what happens with “DELETE from players”?

More about WHERE

WHERE clauses can contain multiple conditions



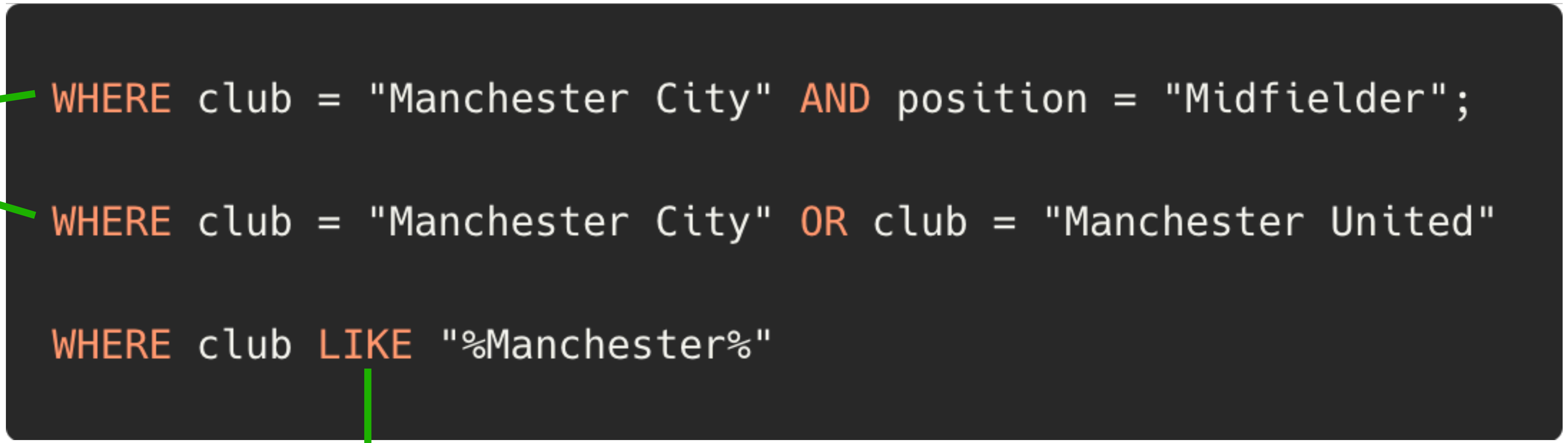
```
WHERE club = "Manchester City" AND position = "Midfielder";

WHERE club = "Manchester City" OR club = "Manchester United"

WHERE club LIKE "%Manchester%"
```

More about WHERE

WHERE clauses can contain multiple conditions



```
WHERE club = "Manchester City" AND position = "Midfielder";

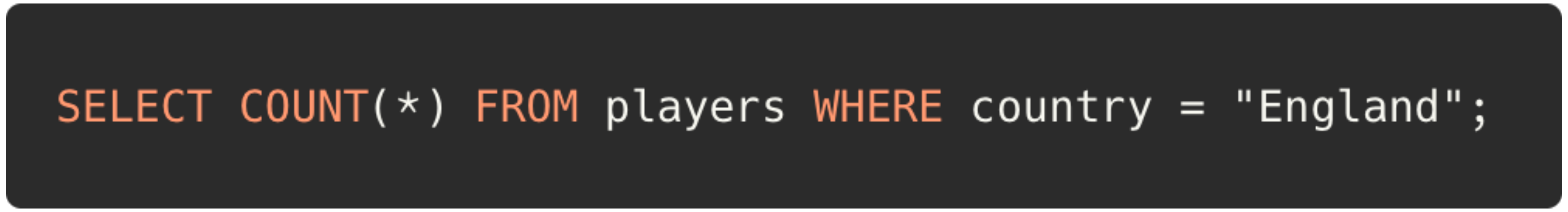
WHERE club = "Manchester City" OR club = "Manchester United"

WHERE club LIKE "%Manchester%"
```

LIKE is an operator for TEXT columns. It will return rows of the table where the value of a field matches the following specifier (i.e., “%Manchester%”)

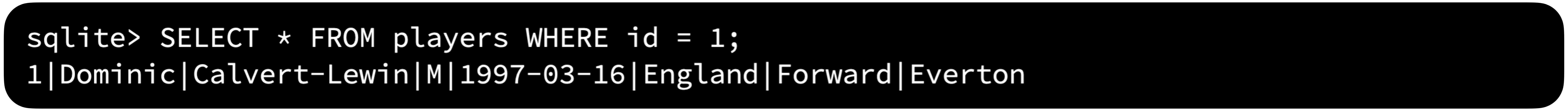
The % symbols are wildcards – they can match any character. So this WHERE clause matches players with clubs with “Manchester” in their name.

Counting Numbers of Records



```
SELECT COUNT(*) FROM players WHERE country = "England";
```

`COUNT` counts the number of records matching the WHERE clause.
If we omit the WHERE clause, it will count the number of records in the table.



```
sqlite> SELECT * FROM players WHERE id = 1;
1|Dominic|Calvert-Lewin|M|1997-03-16|England|Forward|Everton
```

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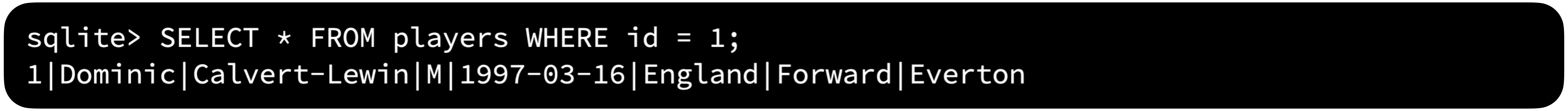
```
sqlite> SELECT * FROM players WHERE club = "Manchester City" AND position= "Midfielder";
4|Rose|Lavelle|F|1995-05-14|USA|Midfielder|Manchester City
9|Kevin|De Bruyne|M|1991-06-28|Belgium|Midfielder|Manchester City
```



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1|Dominic|Calvert-Lewin|M|1997-03-16|England|Forward|Everton
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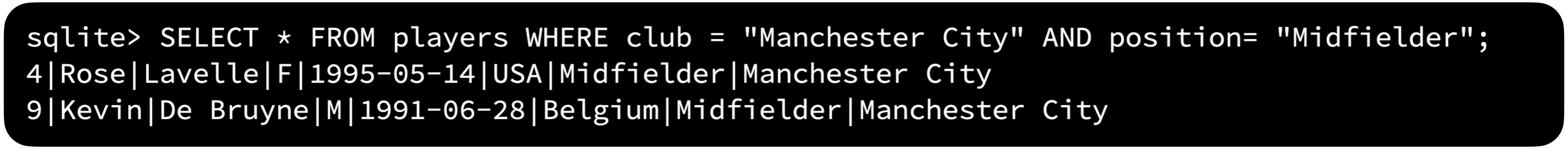

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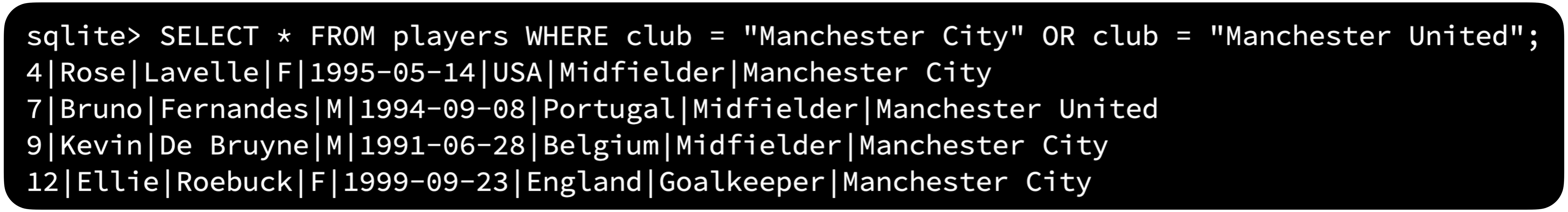

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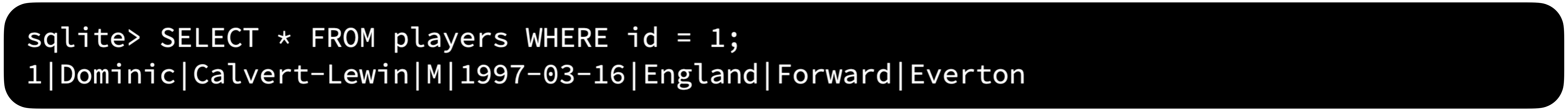

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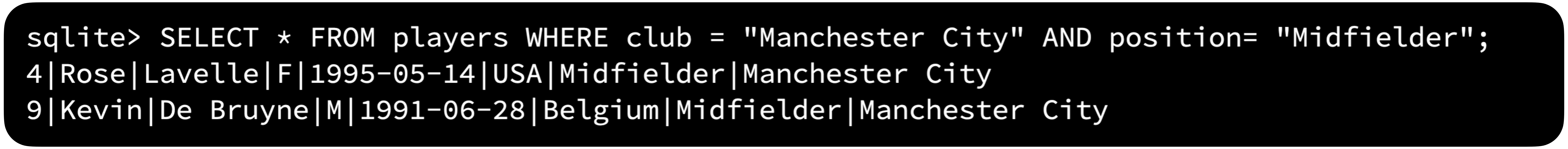

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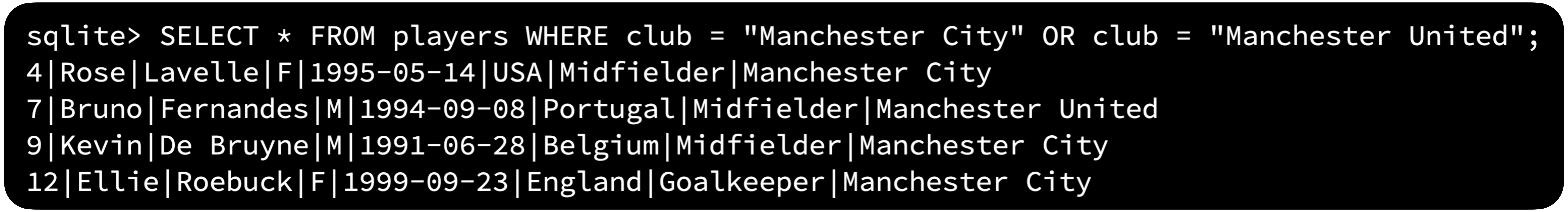

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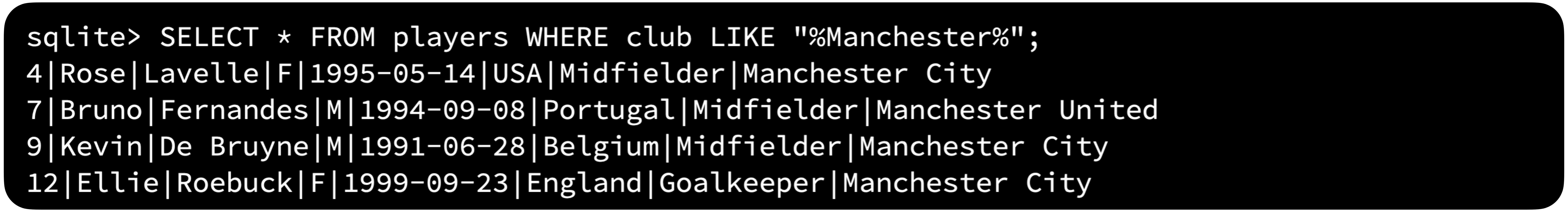

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```
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4
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```
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12
```

id	first_name	surname	gender	date_of_birth	country	position	club
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2	Sam	Kerr	F	1993-09-10	Australia	Forward	Chelsea
3	Harry	Kane	M	1993-07-28	England	Forward	Tottenham
4	Rose	Lavelle	F	1995-05-14	USA	Midfielder	Manchester City
5	Son	Heung-min	M	1992-07-08	South Korea	Forward	Tottenham
6	Pernille	Harder	F	1992-11-15	Denmark	Forward	Chelsea
7	Bruno	Fernandes	M	1994-09-08	Portugal	Midfielder	Manchester
8	Hayley	Raso	F	1994-09-05	Austrailia	Midfielder	Everton
9	Kevin	De Bruyne	M	1991-06-28	Belgium	Midfielder	Manchester City
10	Vivianne	Miedema	F	1996-07-15	Netherlands	Forward	Arsenal
11	Michael	Keane	M	1993-01-11	England	Defender	Everton
12	Ellie	Roebuck	F	1999-09-23	England	Goalkeeper	Manchester City

databases/football_players.sqlite3